LIST OF CONTRIBUTORS.

BURCHARD, HENRY H., M.D., D.D.S.;

ESSIG, CHARLES J., M.D., D.D.S.;

EVANS, W. W., D.D.S.;

GODDARD, C. L., A.M., D.D.S.;

MOLYNEAUX, GRANT, D.D.S.;

OTTOLENGUI, RODRIGUES, M.D.S.;

TEES, AMBLER, Jr., D.D.S.;

THOMPSON, ALTON HOWARD, D.D.S.

THE

AMERICAN TEXT-BOOK

OF

PROSTHETIC DENTISTRY.

IN CONTRIBUTIONS BY EMINENT AUTHORITIES.

EDITED BY

CHARLES J. ESSIG, M.D., D.D.S.,

PROFESSOR OF MECHANICAL DENTISTRY AND METALLURGY, DEPARTMENT OF DENTISTRY,
UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA.

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SEVERAL CONTRIBUTORS

THIS VOLUME IS INSCRIBED AS A RECOGNITION

OF

PROFESSIONAL EMINENCE AND PRIVATE WORTH

TO

LOUIS JACK, D.D.S.,

BY HIS FRIEND AND FORMER ASSOCIATE

THE EDITOR.

September 12, 1896.

PREFACE.

IF the Editor interprets correctly the prevailing opinion of the dental profession as reflected in the utterances of many teachers, the issue of an extended and strictly modern text-book upon the Principles and Practice of Prosthetic Dentistry will answer a need of the times. During the past thirty years the practice of prosthesis has undergone a transformation parallel with that of operative dentistry during the same period. Plans, operations, and methods which, despite the retrospective asseverations of many, were but crude and indefinite, have received a development which has widened this branch of dental practice and greatly increased its utility.

There is contained in the body of the present volume the material which a consensus of opinion declares the best that dental prosthetic art has evolved. It is designed to answer the purposes of a text-book for the under-graduate student, a clear and thorough laboratory manual, and a work of reference for the dental practitioner.

In conformity with these plans, the central object is the exposition of principles and the teaching of their practical application. No effort has been spared by Editor and collaborators to survey, arrange, and classify the mass of data gleaned from the literature of the past fifty years and from the practice of those who have raised prosthetic dentistry to its present plane.

In arranging this vast accumulation of material so that one case might be correctly placed as representative of a class, matters which are not directly pertinent to the subject of laboratory technology are deliberately excluded from these pages, it being confidently believed that a mastery of the technique and materials presented will give the student a command of the subject throughout its many ramifications. The means employed to this end are lucidity of description and such a wealth of illustration as to render the text as clear as words and pictures can make it. Particularly in the matter of engravings the publishers have been more than liberal, desiring that the book should, above all, fill the gap complained of by teachers—the want of a complete and modern text-book from which obsolete and useless material should be expunged.

It is a prominent purpose of the work to sift from the multitudes of devices and operations which have been advanced, those which have so stood the test of time as to receive the endorsement of continued application by the most skilled and experienced prosthetists, and to describe in detail those principles which are applicable to the greatest number of cases. From the beginning of dental journalism the pages of periodicals have teemed with processes conceived and advanced with the avowed purpose of time-saving. A careful examination and test of such methods has exhibited one strikingly common feature—namely, that economy of time, when made the main purpose, is generally effected at the expense of accuracy. The demand for precision is quite as imperative in dental prosthesis as in any other art, and it is evident, therefore, that the saving of time should be made a subordinate motive. These observations apply with peculiar force to the department of artificial crowns and bridge-work. The past twenty-five years have created in these subjects alone a literature embracing sufficient material to make a volume much larger than this. Such literature has been carefully examined, and is here reduced from its many ramifications into basal principles and their embodiments, which will be found to include all those devices which have merited and found actual and continued clinical use.

Prosthetic Dentistry, it is almost needless to state, is more than a mere mechanical art, for, contrary to the nature of such arts, there are but few entirely constant rules upon which its practice may be based. Rarely is any operation in this art an exact repetition of a preceding one, the resemblance which one case bears to another being more often remote than close. The taste, experience, and judgment required for the proper practice of prosthetic dentistry place it in near kinship with one of the fine arts.

Full credit for sources of information has been accorded by the contributors in their several chapters. In addition to these, the Editor tenders his grateful thanks for favors and courtesies extended by Prof. S. H. Guilford, Dr. John N. Farrar, Dr. Eugene S. Talbot, Prof. E. H. Angle, Dr. Norman W. Kingsley, Prof. E. C. Kirk, and especially to Prof. H. H. Burchard for assistance rendered in the editorial work and in the revision of proofs; also to Dr. N. S. Essig for his valuable assistance in the preparation and revision of illustrations.

Acknowledgment of obligation and thanks are due and proffered to the S. S. White Dental Manufacturing Co.; the Buffalo Dental Manufacturing Co.; the Wilmington Dental Manufacturing Co.; and to Messrs. Johnson & Lund.

CHARLES J. ESSIG.

PHILADELPHIA, August, 1896.

LIST OF CONTRIBUTORS.

HENRY H. BURCHARD, M. D., D. D. S.,

Special Lecturer on Dental Pathology and Therapeutics, Philadelphia Dental College, Philadelphia.

CHARLES J. ESSIG, M. D., D. D. S.,

Professor of Mechanical Dentistry and Metallurgy, Department of Dentistry, University of Pennsylvania, Philadelphia.

W. W. EVANS, D. D. S., Washington, D. C.

C. L. GODDARD, A. M., D. D. S.,

Professor of Orthodontia, College of Dentistry, University of California, San Francisco.

GRANT MOLYNEAUX, D. D. S.,

Professor of Prosthetic Dentistry and Metallurgy, Ohio College of Dental Surgery, Cincinnati.

RODRIGUES OTTOLENGUI, M. D. S., New York.

Editor of the "Items of Interest."

AMBLER TEES, Jr., D. D. S.,

Lecturer on the Continuous-gum Method, Department of Dentistry, University of Pennsylvania, Philadelphia.

ALTON HOWARD THOMPSON, D. D. S.,

Professor of Dental Anatomy, Kansas City Dental College, Kansas City, Mo.

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PROSTHETIC DENTISTRY.

CHAPTER I.

THE MECHANICAL LABORATORY, ITS EQUIPMENT AND ARRANGEMENT.

By Charles J. Essig, M. D., D. D. S.

It is highly important that the furniture and equipment of a dental laboratory should be neat, appropriate, and adapted especially to the comfort of the workman and to cleanliness and celerity in his manipulations. In order to correct the want of uniformity in methods and results which is a noticeable feature of the average dental laboratory operations, students should in the very beginning be taught to be systematic in the care of tools and instruments, as well as in all the manipulative stages of their work. They should be required to find suitable places for every article which enters into laboratory work, so that when not in use tools and apparatus should be returned to the places assigned them.

The usual equipment of a dental laboratory consists in a suitable work-bench carefully adapted to the purposes for which it is to be used; a moulding-box; plaster-table and sink; a swaging-block and anvil; at least two lathes, one designed especially for the grinding and fitting of teeth, the other for finishing and polishing only; a mechanical blowpipe table, supplied with gas-burner on the Bunsen principle, of sufficient capacity to allow of the soldering of full dentures.

In addition to these permanent articles of laboratory furniture it will be necessary to provide a suitable furnace for the melting of zinc, lead, and alloys commonly used in making dies and counter-dies, and also another and different one to be used for the occasional melting of gold and silver and in the formation of alloys to be used as solders.

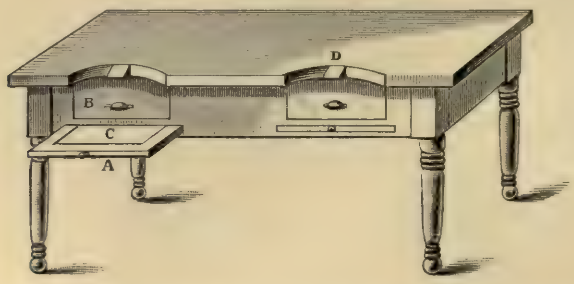
The accessories of soldering, moulding rings and flasks, ingot-moulds, rolling-mills, draw-plates, pickling solutions, with the most suitable vessels for holding the same, grinding and polishing materials, fluxes, varnishes, adhesive wax, and bench tools, all necessarily form part of the equipment of the dental laboratory, and will each be separately described in these pages.

The work-bench should be constructed of cherry, ash, or well-seasoned oak: it should be provided with not less than two sets of drawers, as

2

shown in the diagram, the two lower ones (Fig. 1, A) being reserved for the reception respectively of gold and silver scraps and filings, while the upper drawers (Fig. 1, B) will be found convenient for the reception of the ordinary bench tools, such as pliers, shears, plate-punches and cutters, horn mallet, etc. The drawers (A) should be 20 inches long by 15 inches wide, inclusive, and should consist of a frame of cherry or oak 2 inches wide by 1 inch thick and a tray (C) of tin or zinc 1 inch in depth. By this means the workman is provided with a spacious tray which he

Fig. 1.



draws out to cover his lap in a manner to catch the filings and cuttings of the precious metals while he works.

The height of the work-bench should be about 34 inches, and in length, when designed for the convenience of two workmen, about 5 feet 6 inches; the width may be 24 inches. The top should be 2 inches in thickness, and immediately over the tool-drawers (B) should be arranged a rest for convenience in filing and finishing. These rests are usually made of the same hard wood as the top of the bench, 2 inches wide and about 3 inches long, tapering from $1\frac{1}{2}$ inches in thickness where it is mortised into the table to $\frac{1}{2}$ an inch at its extremity. (See Fig. 1, D.)

Accessories of the Work-bench.—A good vise is an important adjunct to the work-bench, and is indispensable when the draw-plate is used for reducing the size of gold, platinum, or silver wire.

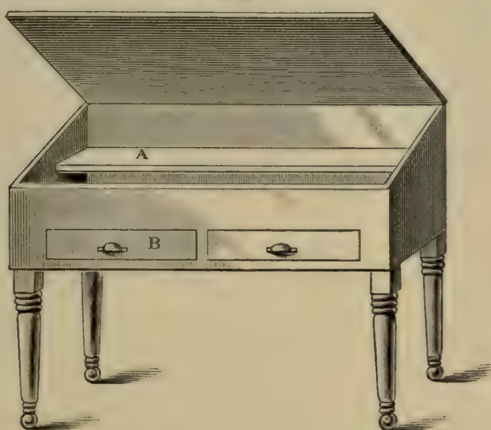
Rubber slabs of $\frac{1}{2}$ an inch in thickness by 6 inches square afford excellent rests, not only for the protection of the top of the bench from injury by contact with dies and counter-dies in the preliminary stage of plate-making, but also as pliant and elastic rests for the metallic or rubber denture during stoning and finishing.

Moulding-box.—This article of laboratory furniture, shown by Fig. 2, demands special attention in its construction, otherwise it will prove a constant annoyance, as no ordinary wooden box will remain tight enough to prevent the moulding sand from falling through its seams upon the floor. The diagram shows the general design of one which has been found practical and convenient. It is 4 feet long, 26 inches wide, and 36 inches high. It is *lined with sheet zinc*, which does not rust by contact with the moist sand, and effectually prevents the escape of the latter. It is provided with a shelf (A), upon which each completed mould may be placed while others are being prepared or until ready for the casting. It has two drawers (B), 18 inches wide by 4 inches deep, in which may be kept either plaster or the smaller moulding-flasks, rings, and other acces-

sories of the moulding operation. It is provided with a lid, and should be kept closed when not in use, so as to exclude all foreign substances which might seriously interfere with casting.

Accessories of the moulding-box consist of the various sizes of the "Baily moulding-flask," which, with the method of using them, will be described under the head of dies and counter-dies; one Hawes flask (see page 313) and two or three sections of galvanized iron stove-piping, each having the dimensions of about 6 inches in length by $4\frac{1}{2}$ inches in diameter. This simple form of flask is very desirable for many moulding operations of the dental laboratory, its value consisting in the fact that it will accommodate all sizes of models, and that it is less liable, on account of the greater quantity of moulding sand required by it, to the "bubbling"

FIG. 2.



which often occurs when melted zinc is poured in contact with the scant and tightly-packed sand in the "Baily flask."

It is essential that all moulding operations should be performed upon perfectly level surfaces, and for this purpose two or three "moulding-blocks" of seasoned pine, 8 inches square by 2 inches thick, will be found convenient aids. In order to avoid lumpiness and to secure uniformity of condition in the sand when moistening it preparatory to moulding, a sieve of not less than 12 inches in diameter, with meshes of a minimum size of $\frac{1}{16}$ of an inch, will be found of value. The sieve should be formed of brass or copper wire, as an ordinary iron-wire sieve will soon become useless from oxidation, which is greatly assisted by contact with the wet moulding sand. A painter's brush, $1\frac{1}{2}$ inches in diameter by 2 inches in length, will be found useful and convenient for the purpose of removing adherent particles of moulding sand from the surface and interstices of the plaster model each time it is drawn from the sand matrix.

Anvil and Swaging-block.—As the laboratory is often situated on an upper floor, the use of the hammer in swaging plates may be the cause of much annoyance from noise and vibration. This, however, can be entirely avoided by interposing rubber between the block and the floor upon which it rests. Fig. 3, A, shows the block of pine or poplar

wood, $7\frac{1}{2}$ inches square by $23\frac{1}{2}$ inches high. B and C represent a sheet of rubber $8\frac{1}{2}$ inches square by $1\frac{1}{2}$ inches thick, securely fastened to the lower end of the block by screws. This block fits into a box made of $1\frac{1}{2}$-inch pine boards, broader below than above (Fig. 4, D), furnished with a loose bottom, made of 2-inch seasoned oak or ash, and provided with four pieces of solid rubber cylinder (Fig. 3, F) $1\frac{1}{2}$ inches in diameter by 2 inches

FIG. 3.

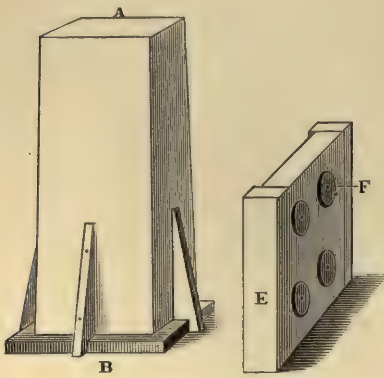
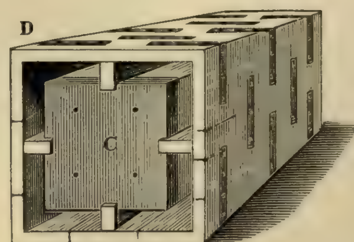


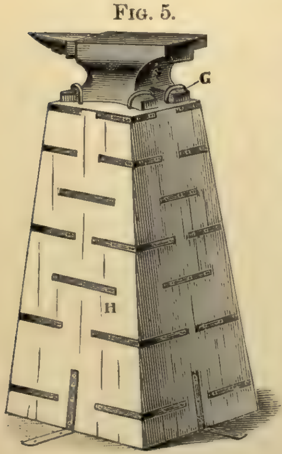
FIG. 4.



long, let into it by holes of the same dimensions bored to a depth of $1\frac{1}{2}$ inches. Two thicknesses of rubber are thus interposed between the block upon which the anvil rests and the floor of the laboratory, and so much of the sound due to the percussive force of the hammer is thereby deadened that scarcely any noise or vibration will be observed by persons in other parts of the house.

The anvil (Fig. 5), which should weigh not less than 40 pounds, may be securely fastened to the block upon which it rests by strong iron staples (G), and the box or outside covering of the block reinforced by iron bands, as shown in H. A swaging block so constructed may be looked upon as a permanent piece of laboratory furniture, and one that will not be likely to get out of order. Two swaging hammers are required—one, weighing about 2 pounds, is of much use in starting the plate. The heavier one, which should weigh $5\frac{1}{2}$ or 6 pounds, is used with greater force after the plate has been made to partially conform to the zinc die when there is no longer danger of its pleating or folding.

FIG. 5.



Plaster-table and Sink (Fig. 6).—The working of plaster, which forms so important a part of the operations of the dental laboratory, is entitled to much more care and attention than it usually receives at the hands of the mechanical dentist. It may be employed with neatness and precision, when its results become truly artistic, or, as is too often the case, it may be handled in so slovenly and untidy a manner as to greatly lower the

standard of results, and, unless kept carefully within the precincts assigned it, cause the laboratory to become a most unattractive place. It is of importance, therefore, that a suitable table be provided upon which the casting and subsequent trimming of plaster models and other parts of the laboratory work depending upon the employment of plaster may be performed. The plaster-table should also be supplied with a sink and receptacle for the cuttings and refuse fragments. The accompanying diagram shows such a table and sink which the author has found to be practical and convenient. It has been designed especially to protect the floor and other parts of the laboratory from contact with plaster. It is 31 inches high, 23 inches wide, and 27 inches long, and has an opening (A) 8 inches by 8 inches square, under which rests a

Fig. 6.

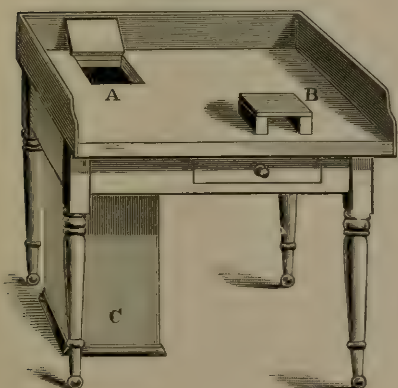


Fig. 7.

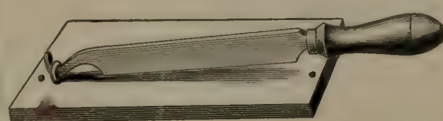
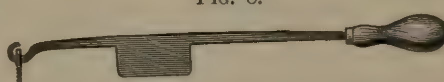


Fig. 8.



portable box (C), 12 by 12 inches square, intended to receive all cuttings and refuse plaster.

The table is provided with a small rest (B) for convenience in resting the model while trimming to proper dimensions. It is also provided with a drawer for the reception of plaster knives, spatulas, and camel's-hair brushes used in mixing plaster and in casting and trimming models.

The *accessories of the plaster-table*, named in the order in which they are used, consist, first, of two short broad-necked bottles, for sandarac and shellac varnish, two or more flexible rubber plaster bowls, the same number of bone, ivory, or steel spatulas for mixing, one or more "plaster knives," such as are sold at the dental dépôts for the purpose of reducing the size of plaster models, or a bench-knife, as shown in Figs. 7, 8, will be found very effective in cutting down hard plaster in preparing the model for flasking in rubber or celluloid work, and a number of different sizes of camel's-hair brushes, which are indispensable in carrying the plaster into the deeper parts when running or casting impressions for partial dentures, and indeed all impressions having deep and more or less inaccessible points, which might not be perfectly reached by the gravitation of the plaster unassisted by some such means as is suggested by the use of the camel's-hair pencils or brushes.

Two kinds of varnish are usually employed in the preparation of the surfaces of impressions for running out the models, so as to prevent too

close adhesion of one to the other. One is transparent and dries upon the plaster without color. The other is of the color of burnt sienna, and imparts a dark-yellow stain to the plaster. The first is made by dissolving 5 ounces of gum sandarac in a quart of alcohol. The latter is formed of gum shellac and alcohol in the same proportions. Gum sandarac dissolves rather slowly, and requires a good quality of alcohol free from a very considerable percentage of water; otherwise it will have a milky appearance and will not afford a perfectly glazed surface when applied to the plaster impression. These two varnishes are employed for totally different purposes. In running out an impression the object should be to obtain a perfect surface to the model, one that is free from air-bells or roughness of any kind, as such imperfections will be represented on rubber or celluloid dentures by multitudes of minute globules which are highly irritating to the mucous membrane of the mouth. The shellac varnish should be applied first, as it penetrates the plaster and discolors it sufficiently to serve as a guide in removing impressions from models, and thus prevents the workman from injuring the teeth or prominent parts of the model. After the shellac varnish has been allowed to dry the sandarac should be applied with a camel's-hair brush until the surface is glazed. It should be laid on of a uniform thickness, but not in such quantity as to fill up deep places or to injure the correctness of the fac-simile of the mouth.

After the last coat of varnish has been allowed to dry, if the glazing of the surface is satisfactory, the plaster impression merely requires to be dipped in water to ensure saturation and to further harden the varnish, when it is ready for running the model. Careful attention to these details will produce a model possessing hardness of surface and with the glazed appearance which is noticed when plaster is poured and allowed to set upon glass. This result, however, cannot be obtained when oil or solutions of soap have been used: such substances should never be applied to plaster impressions, as they do not afford surfaces sufficiently smooth or hard upon which to form rubber or celluloid dentures. To get the best results in the handling of plaster, the latter in mixing should be slowly dropped into water until it becomes saturated and settles to the bottom of the bowl, so as to expel the air. The surplus of water is then poured off and the plaster well stirred, when it should be carried to the surface of the impression and into the deep parts with a camel's-hair brush, and the balance built up with the spatula.

Plaster of Paris (calcium sulphate, $CaSO_4$) is prepared from a native calcium sulphate, containing two molecules of water of crystallization ($CaSO_4 + 2H_2O$), called gypsum when found in opaque masses, alabaster when it presents a semi-opaque appearance, and selenite when it occurs in transparent prisms. The first is the common source of plaster of Paris. It is prepared by heating the mineral in an oven where the heat does not exceed 127° C. (261° F.), by which the water of crystallization is expelled. It is afterward reduced to a fine powder, and when mixed with water it solidifies after a short time from the re-formation of the same hydrate; but this effect does not happen if the gypsum has been overheated and its affinity for water destroyed. In setting there is always a slight evolution of heat and more or less expansion.

For dental purposes there should be two kinds of plaster provided.

For taking impression of the mouth, a finely-ground plaster is required, which sets quickly, but does not become hard enough to demand a very considerable exhibition of force in its fracture, which is nearly always unavoidable in removing impressions of mouths containing natural teeth and perhaps several dovetailed interdental spaces.

A different quality of plaster is demanded for running models and in vulcanite and celluloid work, which need not necessarily possess the quick-setting property, but in which greater hardness and strength are indispensable requirements. (See page 298.) Plaster when not being used should be kept covered to shield it from occasional dampness of the atmosphere and to protect it from water and foreign substances which might accidentally fall into it. The tin cans in which plaster is furnished by the dental dépôts are admirably suited for this purpose, and no improvement over them need be looked for.

Care of Metals used in the Formation of Dies and Counter-dies.— Zinc and lead are the metals most frequently employed for this purpose, but there are also several alloys which have found favor with some of our most skilful and experienced mechanical dentists. The composition, fusing-points, and physical properties of all of these will be described in another chapter. There are other alloys used in crown- and bridge-work, and these demand special care in their storage and handling. First, it is important that they be kept strictly apart and that separate melting-pots or ladles be provided for each. This is especially true with regard to zinc and lead, two metals which resemble each other so closely that it may easily happen that a zinc die be remelted in a pot already partly full of lead. The necessity for carefully keeping these two metals separate in all moulding operations will readily be appreciated when it is remembered that zinc and lead combine with each other to a very limited extent, and that when melted together and allowed to cool they separate in two layers, the upper, and consequently the lighter one, zinc, retaining 1.2 per cent. of the lead, while the lower layer consists of lead alloyed with 1.6 per cent. of zinc. If by accident lead becomes mixed with zinc used for dies, the lead by its greater specific gravity settles to the bottom and fills up the deeper portions of the sand matrix representing the alveolar ridge, the most prominent part of the die. This may not be discovered until an attempt to swage is made, when the die will be found to be totally unfit for the purpose. In such cases the mixed metal should be discarded and new zinc substituted. Lead belongs to a small class of metals which are so soft that they can be scratched by the finger-nail, while zinc is so much harder that no impression can be made upon it by that means. This simple test is therefore an excellent way of deciding between lead and zinc as they appear in the pot or ladle after having been previously melted.

In casting metals of the class to which zinc and lead belong their fusing-point should be borne in mind, so that they may not be subjected to temperatures greatly in excess of that which is sufficient to melt them; otherwise partial oxidation will occur, which greatly impairs the working qualities of the metals by rendering them viscid and difficult to pour when fused, and so brittle after casting as to be unfit to bear the blows of the swaging hammer without breaking.

While the metals used in the formation of dies and counter-dies are

melting they should be watched, and, when the last solid portion becomes fluid, removed from the furnace and allowed to stand for a few moments until the fused metals are observed to crystallize at the edges, when they are in the proper condition for casting; for when zinc or lead are poured at a temperature greatly in excess of their fusing-points the shrinkage of the die is not only greater, but the amount of vapor generated by contact with the moist moulding sand is very likely to cause "bubbling," which is nearly always fatal to the die.

The Precious Metals.—Scraps and filings of the precious metals, such as gold, platinum, and silver, should be kept free from contamination with particles of zinc, lead, or tin, which metals are constantly being used about the work-bench, while at the same time admixture with each must be avoided. Small pieces of pattern tin or fragments cut from dies and counter-dies, when overlooked and melted with either gold, silver, or platinum, reduce their fusing-points, lessen or destroy ductility and malleability, and greatly modify color. With the utmost care it is almost impossible to maintain the standard of these metals, and a remelting of scraps and filings of gold taken from the drawer of the work-bench will always be found to be below the grade of the plate from which they were cut: this is partly due to impurities such as have been referred to, fragments of steel from the files used, and the solder employed in the construction of the plate, more or less of which invariably finds its way into the gold drawer in reducing the plate to its proper dimensions. When it becomes necessary to remelt scraps for the construction of backings, for instance, filings should be excluded altogether, and only clean scraps, free from solder, should be selected.

Modes of Melting Metals.—The means employed for this purpose will depend upon the character of the metal or alloy to be fused. The fusing-point of such alloys as are used for dies and counter-dies in crown- and bridge-work, which melt at temperatures ranging from 158° F. to 236° F.—and there are no less than six of these alloys now in use—may be accomplished by simply placing a sample of any one of them in a small iron ladle provided with a suitable handle, and holding it over a gas-jet or the flame of an alcohol or oil lamp, or, in the case of zinc, lead, or Babbitt's metal, in an ordinary stove or furnace, or, better still, when gas is available, by one of the gas-furnaces devised by Mr. Fletcher of Warrington, England, for melting

Fig. 9.

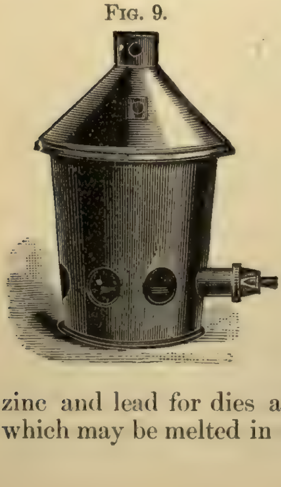


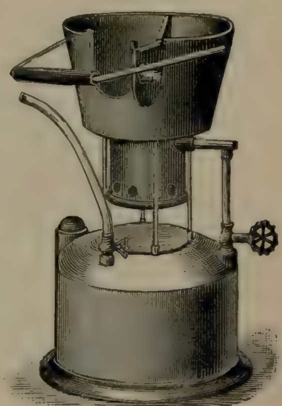
Fig. 10.

zinc and lead for dies and counter-dies and for the fusion of all alloys which may be melted in an iron ladle at or below red heat.

Figs. 9 and 10 show an improved form of furnace with ladle for melting zinc, lead, and other metals for dies and counter-dies, which is believed to be a better furnace for that purpose than any other yet made. It works equally well with any gas-supply available; the speed of working is, however, proportionate to the supply of gas. The burner can be removed from the casing and used for other purposes if desired.

When gas is not available, the gasoline furnaces used by plumbers for melting solder have no superiors in point of convenience and rapidity, while the cost of the fuel is very slight. Fig. 11 gives an illustration of this furnace. The lower portion is a galvanized reservoir which holds the gasoline. In the top of the reservoir is a stopcock with a short rubber tube attached, through which air is forcibly blown for a moment until pressure is made upon the surface of the gasoline, which forces it out through a tube continuous with the supply-tube of the burner reaching from the bottom of the tank, and conveys it to the burner, the supply to which is regulated by a valve. The burner is so constructed that the flame from the burning jet of gasoline is projected upon a recurved portion of the supply-tube, which is heated thereby to a temperature sufficient to vaporize the gasoline before it makes its exit at the jet. The result is a large volume of gasoline vapor under high pressure, burning with an intensely hot flame, without any disagreeable odor, and with more than ample heating power for the requirements of the case. When once started the action is perfectly automatic. The cast-iron shell around the burner directs the heat toward the sides of the melting-ladle, which stands within it and upon a support immediately above the flame. A gauze packing in the exit-tube interposed between the burner and the gasoline reservoir prevents any danger of ignition of the fluid in the latter while the furnace is in action. The form of this furnace, made by C. Gefrorer, Philadelphia, is admirably adapted for use with the Baily melting-pots commonly used in the dental laboratory.

FIG. 11.



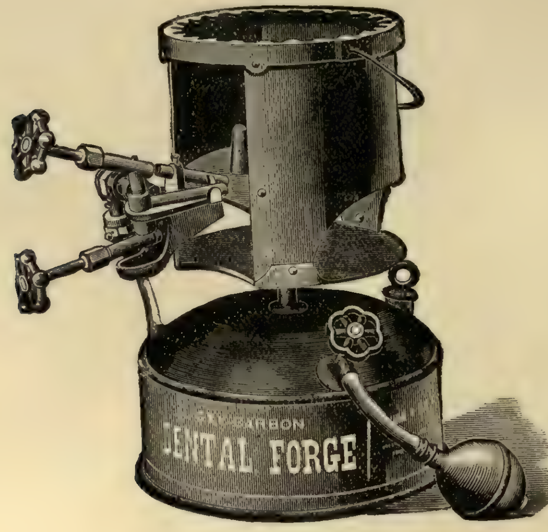
"The oxycarbon dental furnace" (Fig. 12), for use by dentists who are located where gas is unattainable, will be recognized as an improved form of the preceding furnace. It gives a strong, steady, and continuous heat, the flame being smokeless and nearly odorless, and is capable of continuous use, if required, without any attention save an occasional compression of the rubber bulb to keep up the pressure upon the contents of the reservoir. When put to continuous use for a day it will consume about half a gallon of gasoline. It is claimed for this furnace that it is entirely effective in the melting of gold or silver, preparing zinc dies, annealing plates, heating up invested dentures preparatory to soldering, and for all purposes of the dental laboratory requiring strong heat.

It should be remembered that zinc will, under favorable conditions, unite with iron, and it frequently attacks the cast-iron ladle in which it is melted, and may penetrate the side and escape into the fire. Accidents

of this kind are more likely to occur when the ladle is new, and may be avoided by coating the inside with whiting previous to the first melting.

The melting of metals which require very high temperatures must necessarily be accomplished in crucibles. These are made of clay with

Fig. 12.



The carbon furnace.

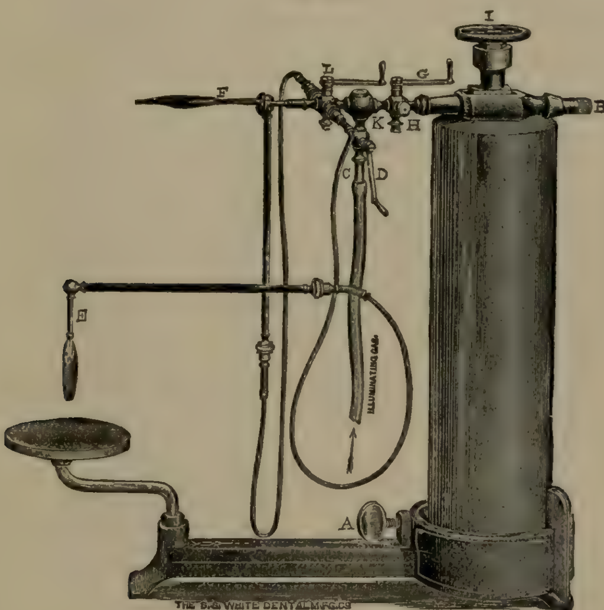
admixture of silica, burnt clay, graphite, or other infusible material. A crucible should possess the power of resisting high temperatures without fusing or softening. It should also be capable of retaining sufficient strength when hot to prevent its crumbling or breaking when grasped by the tongs. Lastly, it should not crack either in heating or cooling. For the fusing of platinum, which requires the intense heat of the oxyhydrogen flame, they are formed of blocks of thoroughly burned lime. The furnace usually employed, shown in Fig. 105, also serves the purpose of a crucible. In form it may be described as a sort of basin or concavity with a similar piece for a cover. The lower part is intended for the reception of the metal; through the centre of the upper portion or cover pass the tubes for the oxyhydrogen jet, while the lower portion is provided with a lip or spout for pouring the melted metal. The tubes which pass through the top for the transmission of the two gases are generally formed of copper with platinum tips. The outer and lower tube carries hydrogen, while the inner and upper one carries a jet of oxygen into the middle of the flame. The tubes are furnished with stopcocks, so that the supply may be regulated. When the object is merely to fuse some scraps of platinum, the lime-furnace is first put together; the hydrogen jet is lighted; oxygen is then turned on, and the interior of the apparatus soon becomes heated. The platinum is then introduced in pieces through a small hole at the side, and quickly fuses after entering the furnace.

The ingot-mould used in casting melted platinum is usually formed

of coke or pieces of lime or graphite, and the furnace is arranged on centres, so that it can be tilted sufficiently to allow the fluid metal to flow into the mould.

The form of oxyhydrogen blowpipe invented by Dr. J. R. Knapp, shown by Fig. 13, is a complete and effective apparatus for soldering and melting operations in the dental laboratory. It may be used with equal facility in soldering the largest piece of plate-work or the most delicate crown-work, and is of particular value to dentists who give attention to continuous-gum work, enabling them to readily remelt their platinum

Fig. 13.



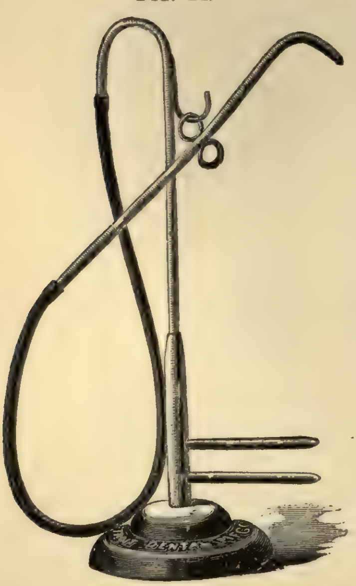
scraps. It is provided with an iron stand, in which is secured by a thumb-screw a 100-gallon cylinder of nitrous-oxide gas. By means of a yoke and set-screw the valve of the cylinder is connected with the tubes and valves of the blowpipe in such a manner that the proportions of a mixture of nitrous-oxide and illuminating gases are under perfect regulation and control. A cylinder of nitrous-oxide gas is placed in the base or stand, and fastened with the thumb-screw A. The yoke carrying the stopcocks and valves is attached to the valve of the cylinder and tightened with the screw B. The pipe C is connected by a rubber tube to an illuminating-gas bracket. When the apparatus is in use the illuminating gas is turned on, and its flow regulated by the handle D. The handle G over the outlet H is then turned; the cylinder valve is opened by means of the hand-wheel I sufficiently to permit the escape of enough nitrous-oxide gas to be detected by touching the opening H with the finger.

When the desired quantity of nitrous-oxide gas is obtained, the flow is directed to the mixing chamber and controlled by the handle G, which, when in position, as shown in the cut, allows the gas to pass freely into

the chamber K, where it mixes with illuminating gas. Either or both of the burners may be used and the desired flame obtained by regulating the pressure of the gases by the handles controlling them. It is an instrument of much greater delicacy than the blowpipes commonly used by dentists. The flame which it affords is very small, but the intensity of its heat is such that great care must be exercised in soldering small objects to prevent "burning" or even entire fusion of the parts adjacent to the solder. It is economical of time and materials, and its perfect cleanliness will commend it to all who work in the higher branches of mechanical dentistry.

Dr. J. H. Downie has devised a neat and efficient nitrous-oxide blowpipe (Fig. 14), which is a simplified form of the preceding. The advantages claimed for it are that there is so little force required for the blast that the solder and borax are never blown out of place, and yet the heat is so intense that all soldering operations of the dental laboratory may be accomplished without delay or the least difficulty, and that its simplicity prevents any part of it from getting out of order. The coal gas is supplied by connection with one of the tubes shown in the cut, and the nitrous oxide to the other. The amount of nitrous-oxide gas required is so small that it need scarcely be taken into consideration. It may be used in small places where there is no supply of the ordinary illuminating gas by substituting a carburetter furnished by the manufacturers of the blowpipe, which, it is claimed, will run it equally as well as coal gas.

Fig. 14.



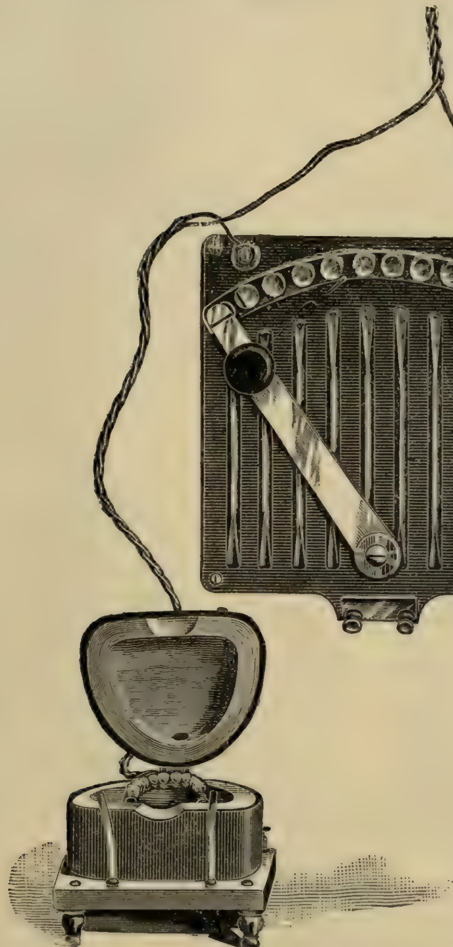
A process of melting platinum for dental purposes, recently devised by Dr. L. E. Custer of Dayton, Ohio, in which electricity is the active agent (Fig. 15), is described by the inventor as follows: "The production of heat by electricity depends upon two factors—the quantity of electricity and the resistance of the conducting agent. As the quantity is increased the heating power is augmented, but this power is not apparent until the current meets with some resistance. The unobstructed flow of any quantity of the fluid does not produce heat. It is only when there is placed in the circuit a poor conductor of electricity that we have this manifestation.

"All metals are comparatively good conductors of electricity, yet they vary in their conducting power, copper[1] representing one extreme and German silver the other. The size of the wire is another factor in the determination of heat: with a given length of wire the resistance increases as the diameter of the wire decreases. In other words, a small

[1] Silver is the best conductor amongst the metals, standing first in the list, with copper second. The alloys are generally poor conductors.

wire has less carrying capacity than a large one, so that when the same amount of current that is easily conducted by the large one is forced through a small wire resistance is met with and heat is produced.

Fig. 15.



"When a current has been established by bringing two terminals together, the electricity continues to flow even after the ends have been separated. It leaps the intervening space and forms a voltaic arc. The heat of the arc is so intense that it is practically without limit. The method herein described is a device for making and using the voltaic arc for melting metals which are infusible at ordinary temperatures. The appliance is adapted to the 110-volt current, that which is used for incandescent lighting, and which is the ideal current for dental purposes. A large quantity of current being necessary, the safety plugs should be as large as No. 16 or 18 standard gauge. A resistance coil of eight pounds of No. 18 copper wire will prevent fusing the plug and at the same time give a large arc. This is placed at a convenient point in the

circuit. It becomes heated, and should be insulated and ventilated on asbestos if used for a considerable length of time.

"A block of carbon, such as is used in batteries, is connected with one wire for the receptacle and a carbon pencil is attached to the other wire. Carbon is used for the receptacle because it is a conductor of electricity, a poor conductor of heat, is non-combustible, and can be easily fashioned to mould the melted metal. The carbon pencil is to be used by the right hand; it is made of an electric-light carbon five or six inches long. A hole is drilled two-thirds its length, and in this hole is inserted the other terminal wire. This wire is so insulated that only the end comes in contact with the carbon. By this arrangement the upper two-thirds of the pencil, although charged electrically, does not become heated and answers for a handle. The platinum is laid on the carbon bed and the pencil is brought in contact with it. Immediately there is a current established from the pencil through the platinum to the carbon bed or *vice versâ*. Upon raising the pencil a short distance an arc is formed directly upon the metal and it is melted. The arc can be carried about at will until the pieces are all brought into one mass.

Fig. 16.

Fig. 17.

Fig. 18.

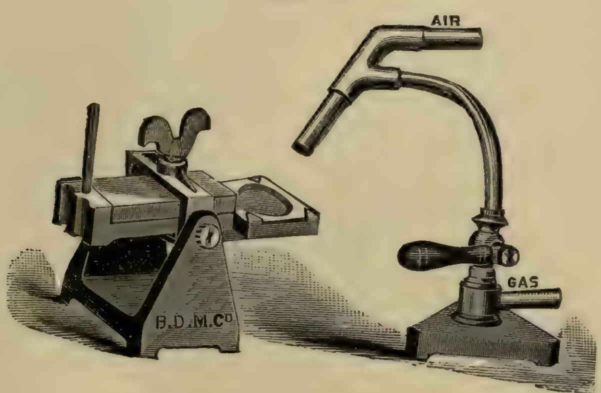
Small quantities of gold or silver may be melted by means of the ordinary blowpipe upon a support formed of charcoal. A good solid

cylindrical piece of thoroughly charred pine coal should be selected, and divided into two equal halves by a vertical cut with a saw, as shown by Figs. 16, 17, 18. Upon the end of one half a depression should be cut for the reception of the metal to be melted (A). On the flat side of the other half, extending to the end, the ingot-mould should be carved, of a size and shape governed by the requirements of the case (B). The two halves should then be brought together and secured by a piece of iron or copper wire, when they will be found to practically combine the requirements of a crucible and ingot-mould.

The depression in which the metal is to be melted and the mould or receptacle should be connected by means of a gutter or groove. The flame of the blowpipe is directed upon the metal, and when thoroughly fluid the charcoal is tilted, so that the fused metal will run into the mould prepared for it in the opposite half of the charcoal. This is probably the simplest form of apparatus by which small quantities of metal can be melted, and is often employed in the dental laboratory and by jewellers.

Mr. Fletcher has devised an apparatus embodying the same general principles as the one just described for quickly obtaining ingots of gold and silver without the use of a furnace (Fig. 19): A representing a

FIG. 19.

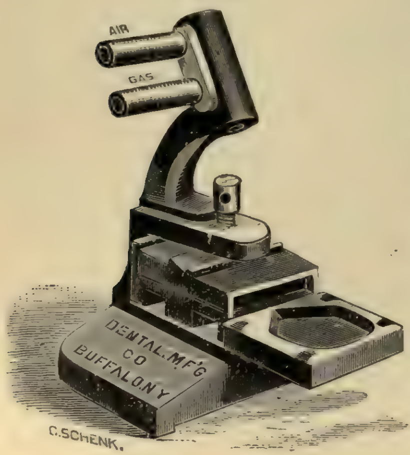


crucible of moulded carbon, supported in position by an iron side-plate; B, the ingot mould; C, clamp holding ingot-mould and crucible in position; D, cast-iron stand upon which the latter swivels. The metal to be melted is placed in the crucible (A), and the flame of the blowpipe is directed upon it until it is perfectly fused. The waste heat serves to make the ingot-mould hot. The whole is tilted over by means of the upright handle at the back of the mould. A sound ingot may be obtained by the use of this simple little apparatus in a very few minutes.

Fig. 20 represents an improved form of the preceding melting arrangement. It differs in that the two parts of the ingot-mould slide on each other to enable ingots of any width to be cast, and the blowpipe is part of the rocking stand. The bellows is connected to the upper tube and the gas to the lower by the usual means of india-rubber tubing.

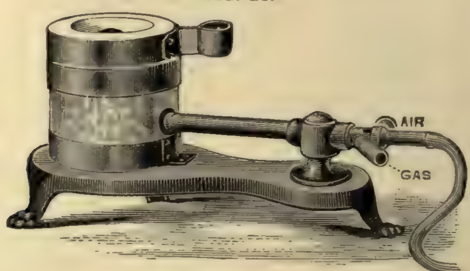
Contrivances of this kind are, however, not applicable to melting operations involving quantities exceeding one ounce. In such cases it is better to employ a crucible and any stove or furnace in which the temperature can be raised sufficiently. This may be accomplished in an ordinary cooking-stove, a blacksmith's forge, or a small fire-clay furnace by the use of anthracite coal, coke, or charcoal.

Fig. 20.



By far the most convenient, compact, and effective furnace for melting from one to ten ounces of gold which has ever been used is the crucible furnace (Fig. 21) invented by Mr. Fletcher, which can be obtained at the dental dépôts. It is perfectly adapted to the wants of the mechanical dentist. It is composed of a substance resembling fire-clay, but much lighter in weight, and said to possess only one-tenth its conducting power for heat. The furnace consists of a simple pot for

Fig. 21.



holding the crucible, with a lid and a blowpipe, all mounted on a suitable cast-iron base. The casing holds the heat so perfectly that the most refractory substances can be fused with ease by the use of a common foot-blower. The power which can be obtained is far beyond what is required for most purposes, and is limited only by the fusibility of the crucible and casing. The graphite crucible made especially for the Fletcher furnace will hold about ten ounces of gold. An ordinary gas-supply pipe of $\frac{5}{16}$- or $\frac{3}{8}$-inch diameter will work it efficiently. It requires a much smaller supply of gas than any other furnace known: about ten cubic feet per hour is sufficient for most purposes. A gasoline generator has been devised by which these furnaces can be satisfactorily used when ordinary illuminating gas is not attainable. Fig. 22 shows the generator attached to the furnace with foot-blower complete. The blast is obtained by means of a foot-blower connected with the blowpipe by a flexible rubber tube. The reservoir of the upper portion,

which holds the air, is, when the bellows is not in operation, merely a disk of thick coffer-dam rubber, which expands under the pressure of the air while the bellows is in motion, and thus affords a very compact, powerful, and effective arrangement. If the rubber disk is distended until forced against the net, as shown by Fig. 23, the pressure can be increased to almost any extent desired. It will give, if required, a heavy and continuous blast through a pipe of a quarter-inch bore.

In size the furnace is but 4 inches in diameter by 3 in height. From six to eight ounces of gold require from seven to twelve minutes for perfect fusion, the time depending on the gas-supply and the pressure of air from the blower.

FIG. 22.

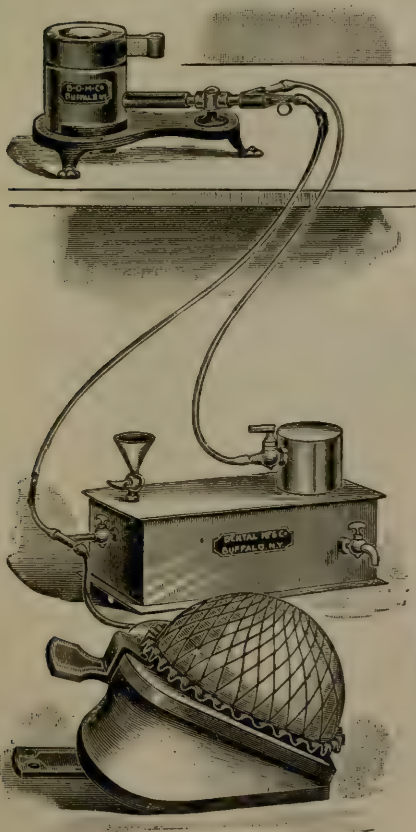
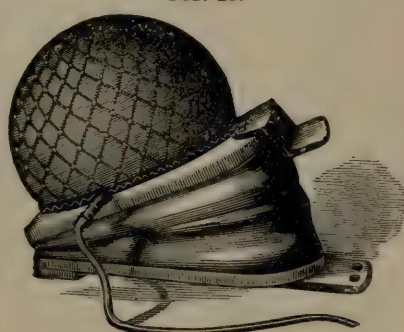


FIG. 23.

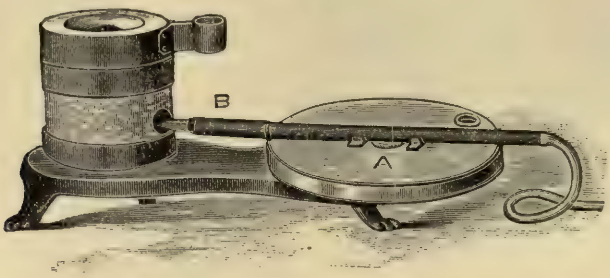


In melting any large amount of gold, particularly if the melting operation is performed in an ordinary coal-stove, there is always danger of loss by the escape of the precious metal through some defect in the bottom or sides of the crucible, when its recovery from amongst the fuel and ashes of the stove is almost impossible; but should such an accident occur when using the Fletcher furnace, the complete recovery of the gold or silver would not be attended with the least difficulty.

A modification of the apparatus has been made, adapting it to the use of refined petroleum instead of gas as a fuel (Fig. 24). Thus improved, it is said to be in no way inferior in efficiency to the gas-furnace. The burner of this furnace is constructed upon the principle of an atomizer, which, of course, dispenses with a wick; it is furnished with a device for regulating the supply of oil which is operated by the milled nut A shown on the top of the reservoir in the cut, and for the supply of an annular jet of air, which is regulated by turning the sleeve (B). This burner is so arranged that in case any obstruction should occur it can be

taken apart and cleaned by separating the burner from the reservoir, which is accomplished by loosening the small screws, drawing out the oil-tube, taking off the sleeve B, and removing the inside tube.

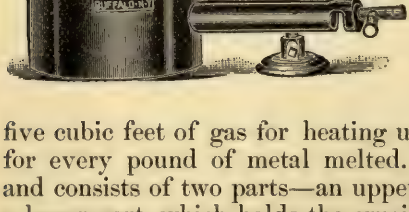
Fig. 24.



These furnaces are so constructed that they may be used for either gas or petroleum, the lamp being fitted for adjustment in place of the gas-burner, so that the same apparatus may be used for either. The blast is obtained by means of the foot-blower, which is connected with the furnace by the india-rubber tubing, as seen in the illustration (Fig. 23).

An injector gas-furnace has also been perfected by Mr. Fletcher, which seems to be well adapted to the wants of the dentist or metallurgist (Fig. 26), and it is claimed that its power and speed of working are practically without limit, depending only upon the gas- and air-supply.

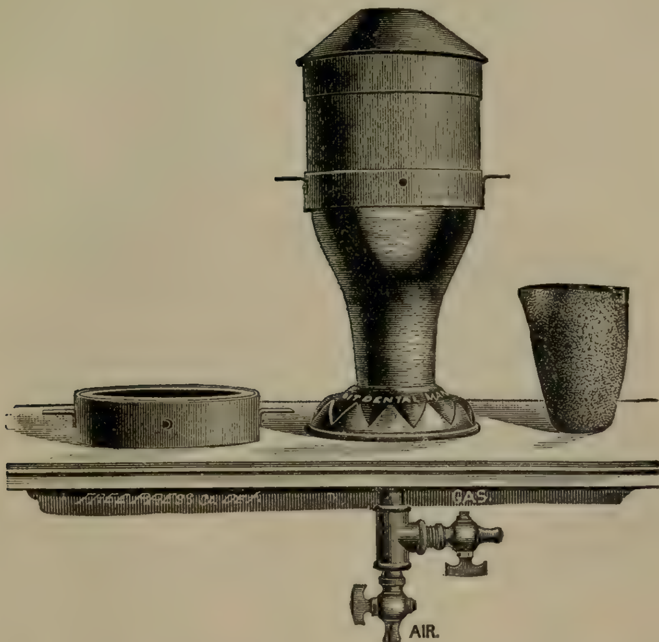
Fig. 25.



With a half-inch gas-pipe and the small foot-blower (see Fig. 23) this furnace will melt a crucible full of cast-iron scraps in ten minutes. The supply of gas required is exceedingly small. Allowing five cubic feet of gas for heating up, it consumes about four feet of gas for every pound of metal melted. It is very simple in construction, and consists of two parts—an upper portion, which forms the cover, and a lower part, which holds the crucible while in operation.

The Downie crucible furnace (Fig. 26) is one of the latest devices especially designed for melting metals, such as gold and silver, making alloys for amalgam, experimental work, etc. It is also very useful in brazing, soldering, heating up bridge-cases or metal plates to solder, etc. It has two removable rings of different widths, which set on above the flaring base to carry the heat up around the crucible, the wide or narrow ring being used, according to the size of the crucible, or both rings may be put on at the same time. It also has a conical-shaped top which can be set on above the rings to confine the heat when it is desired to fuse any substance requiring a high temperature. This furnace can be used for baking continuous-gum or any other porcelain work.

FIG. 26.



Crucibles.—The term "crucible" was originally applied to a chemist's melting-pot, made of earthenware or other material, and so called from the superstitious habit of the alchemists of marking such vessels with the sign of the cross. The term is now generally understood as designating vessels in which metals are melted at high temperatures.

A crucible should possess the power of resisting high temperatures without fusing or softening. It should also be capable of retaining sufficient strength when hot to prevent its crumbling or breaking when grasped with the tongs. Lastly, it should not crack either in heating or cooling.

For the purpose of melting metals crucibles are made of clay with admixture of silica, burnt clay, graphite, or other infusible material. For use in the dental laboratory graphite crucibles, which can be obtained at the dental dépôts, will be found to answer every purpose: they are thoroughly reliable in strength and durability. They range in size from 2 to 4 inches high, and are specially adapted for use in the Fletcher gas-furnaces.

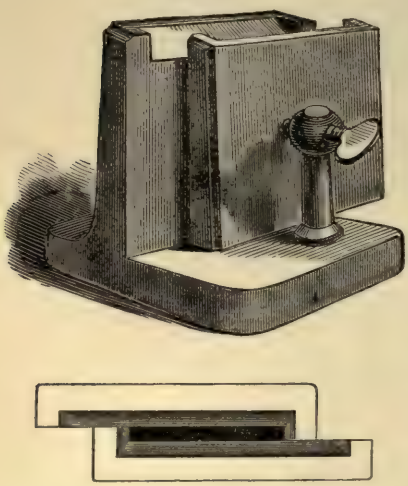
When the quantity of metal to be melted is very small—say, a half-ounce of gold—the smallest-sized Hessian crucible may be used in the small Fletcher apparatus.

Before melting any considerable quantity of gold the crucible should be tested, particularly if the melting operation is to be performed in an ordinary coal-stove, where a defective crucible might be the means of a considerable loss. A small amount of borax should be placed in the vessel, which should then be exposed to a high temperature. Should it

not be perfect, the borax glass will run through and glaze the surface on the outside. If the crucible is found to be impervious, it should be so inverted while yet hot that the borax glass may cover the surface of the lip or groove out of which the melted metal is to be poured. This facilitates the pouring and prevents any portion of the metal from adhering to the side of the crucible.

Ingot-moulds are constructed of various substances. For the reception of platinum melted by the oxyhydrogen blowpipe they are formed of lime or coke; for gold and silver they are commonly made of cast iron, about 2 inches square, and from an $\frac{1}{8}$ to $\frac{3}{16}$ of an inch thick (Fig. 27), with slightly concave inner surfaces, as the shrinkage of the ingot is greatest in the centre. Ingot-moulds formed of soapstone are also employed, but they are not superior to those made of cast iron. Before pouring the ingot-mould should be heated, and when made of cast iron it should be held over a gas-jet or oil-flame until its inner surface is thoroughly coated with carbon: this at once prevents the possible contamination of the gold by contact with the iron, and the carbon layer, being a good non-conductor, protects the melted metal at the moment of pouring from too rapid cooling, which otherwise might be the cause of a defective ingot.

Fig. 27.



The ingot of gold or silver should be as nearly rectangular as possible (Fig. 28), and the operation of pouring the melted metal from the crucible into the ingot-mould cannot be considered as successful unless this result has been attained. The experienced workman holds the ingot-mould, which should be provided with a suitable handle, with the left hand, while with the right he removes the crucible from the furnace

Fig. 28.

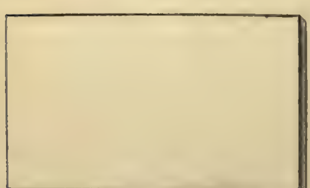
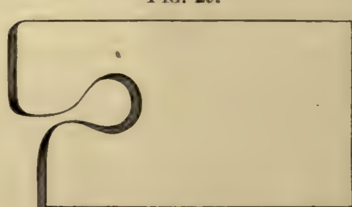


Fig. 29.

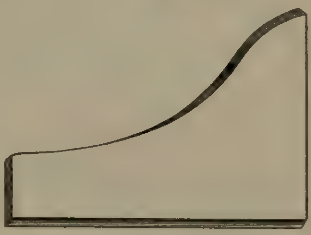


and quickly carries it to the ingot-mould, which he slightly tilts so that the melted metal may first strike the side of the mould; but he quickly brings the mould to a level before the last of the fused metal leaves the crucible, and thus avoids the danger of confining air at the deepest part

of the ingot-mould, which would cause the ingot to assume an irregular shape (Fig. 29).

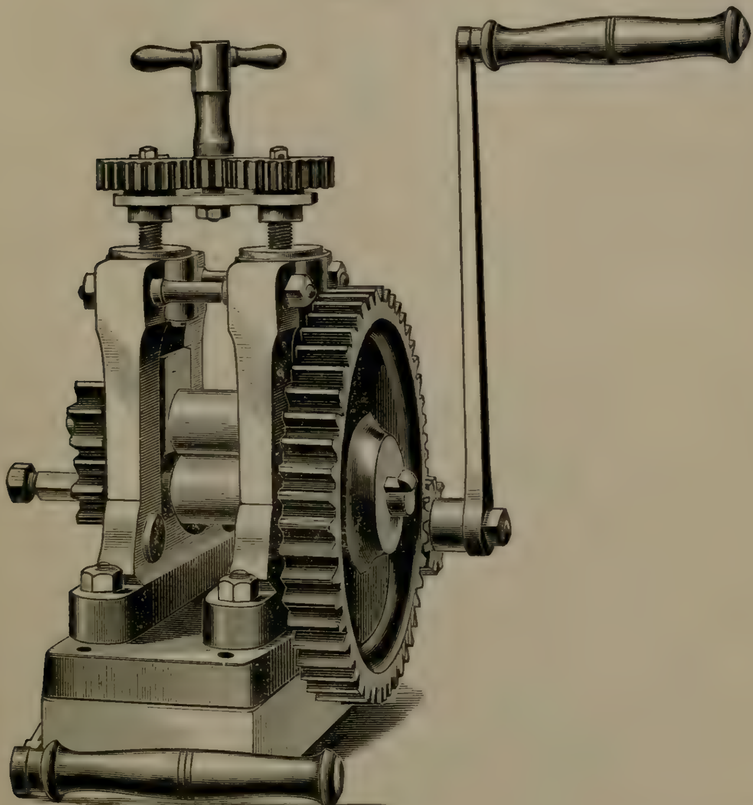
The necessity for heating the ingot-mould just before it is to receive the melted metal becomes apparent when we remember that gold fuses at 2016° F., while the iron ingot-mould at the temperature of the atmosphere would be about 70° F., and when the amount of gold or silver to be melted is but two or three ounces, the ingot-mould, weighing in the neighborhood of twelve ounces, would abstract so much heat from the metal as to cause it to become solid before it reaches the lower part of the mould, and the result would be an ingot triangular in shape (Fig. 30), which could only be rolled at a disadvantage and loss.

FIG. 30.



Rolling or laminating in the dental laboratory is accomplished by repeatedly passing the metallic ingot between cylindrical steel rollers

FIG. 31.



from three to four inches in width. These are so arranged that by means of screws they are capable of being brought closer together every

time the gold is passed through. (See Fig. 31.) The proper degree of attenuation is determined by the gauge-plate (Fig. 32). After the ingot has been passed through the rolling-mill a number of times it cannot be carried through in an opposite direction in order to increase its width without first carefully annealing it. This is done by laying the gold upon a large piece of charcoal and directing the flame of the blowpipe upon it until it becomes red hot. Failure to observe this precaution will invariably result in serious damage to the ingot by splitting.

FIG. 32.

Wire is made by means of the draw-plate, which is formed of an oblong piece of hardened steel provided with a number of gradually diminishing holes enlarged on the side the metal enters (Fig. 33).

FIG. 33.

The metal to be drawn through may be prepared in a cylindrical shape by melting and pouring into an ingot-mould provided with a chamber for the purpose (some ingot-moulds are so constructed). The end of the rod should be filed so as to readily enter the draw-plate, which must be firmly screwed in a vice. The metal is then, by means of strong pliers, drawn through the different holes of the draw-plate consecutively until the desired size is reached. As the work progresses the wire will require frequent annealing, and to facilitate its passage through the draw-plate it must be kept well oiled.

Half-round, square, and triangular wire is drawn in the same manner, except that the holes in the draw-plate are made of these respective shapes, instead of being made round.

Soldering Apparatus and Accessories.—Soldering must also, to a certain extent, be regarded as coming under the general head of melting operations, since it refers to the union of two or more pieces of metal by means of a more fusible alloy. The conditions of successful soldering are—(1) contact of the two pieces to be united; (2) a clean metallic surface over which the solder is to flow; (3) a freely-flowing solder; (4) proper amount and distribution of heat.

Contact of the pieces to be united is of the greatest importance. If, for example, the object to be soldered be an artificial denture, it is indispensable that the backings be quite or very nearly in contact with the plate, and if gum teeth be used that each backing touch its neighbor. This is not difficult to accomplish if the teeth have been carefully and accurately fitted to the plate and to each other. If, however, any defects of this character are found to exist after the teeth have been invested, they should be remedied by filling such spaces or crevices with small pieces of gold or silver, as the case may be, thus rendering the continuity of the parts complete. By the observance of this precaution much of the vexation in soldering experienced by beginners may be avoided, and when the other conditions named have been observed the operation becomes exceedingly simple.

Solder runs freely by the force of capillary attraction between two closely-fitting surfaces, just as water will be drawn against gravity between two panes of glass in close contact. In soldering artificial dentures which have been carefully arranged with reference to contact of all the parts to be united, it is quite possible to complete the operation of soldering without using the blowpipe at all, by merely heating the whole case to the fusing-point of the solder in a charcoal furnace with a good draft. The difficulties of soldering are mainly due to a violation of one or more of the rules herein given.

Cleanliness should always be strictly observed in soldering operations. The parts to be united should present bright and clean surfaces. Darkening or oxidation will always occur when gold or silver the purity of which has been reduced by alloying is heated to redness. A weak solution of sulphuric acid and water, slightly heated, will quickly remove discoloration resulting from this cause, or the borax employed as a flux in soldering operations will effect the same result by dissolving the oxide which forms on the surface, while it also protects it from further oxidation by excluding the oxygen of the atmosphere.

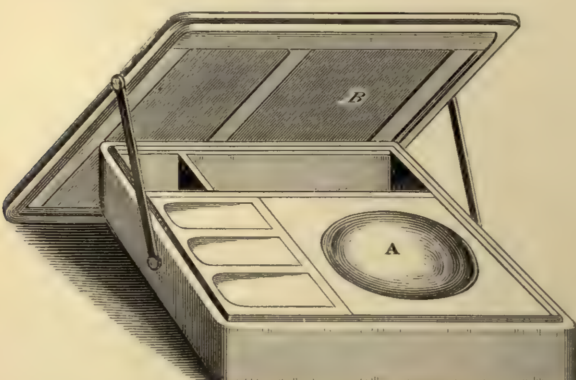
Where broad surfaces are to be soldered together—as, for instance, in the construction of the lower dentures, where, in order to get sufficient thickness, two thin plates are swaged separately and then united by soldering—it is even better, in addition to the pickling process, to thoroughly scrape the surfaces to be united, so as to ensure the flowing of the solder between the two plates. All surfaces to be soldered should receive a coating of borax before the heat is applied.

Borax, which is so indispensable in soldering operations, has the chemical composition of $Na_2B_4O_7,10H_2O$; it is a pyroborate of sodium, and occurs in the waters of certain lakes in Thibet, Persia, and Cali-

fornia. It crystallizes in six-sided prisms, which effloresce in dry air; it dissolves in 20 parts of cold and 6 of boiling water. On exposure to heat the 10 molecules of water of crystallization are expelled; at a higher temperature the salt fuses and becomes glass, in which state it has the power of dissolving metallic oxides; and it is this quality which makes it such an admirable flux in soldering and melting operations. It must, however, be kept scrupulously clean, and especially free from accidental admixture with plaster of Paris. Recently fluxes composed principally of borax, prepared and used in the form of dry powder, have been introduced, but they are in no respect superior to the old way of rubbing up the borax on a piece of ground glass with perfectly clean water until it assumes the consistence of cream, when it is applied to the surfaces to be soldered with camel's-hair brush. A large crystal of borax should be selected for this purpose and given several coats of shellac varnish to prevent efflorescence. Powdered glass of borax is sometimes a useful and convenient adjunct when it is necessary to apply more borax to a hot surface, as in that form it may be dropped with the fingers upon any desired point of the heated denture without danger to the porcelain teeth.

Fig. 34 shows a convenient and compact arrangement designed by Dr. H. H. Keith of St. Louis, Missouri, in which may be kept the borax crystal, the different grades of solder, tweezers for handling small pieces of solder, and camel's-hair brushes. It is provided

Fig. 34.



with a ground-glass plate, depressed in the centre (A), for rubbing the borax with water to the consistence suitable for application to the metallic surfaces to be soldered. When not in use it may be closed with the lid B, which protects the borax from contamination with plaster or other deleterious substances. This neat little accessory of the soldering table is made of walnut wood and is as ornamental as it is useful.

The soldering table is an indispensable piece of laboratory furniture, because it enables the operator to sit while soldering, thus affording a rest for the right arm while the hand guides the blowpipe, and it supplies a convenient place for charcoal "supports" and other soldering accessories. It may be arranged in the form of a mechanical blowpipe, such as were formerly manufactured by the late Mr. Bishop of Phila-

delphia, and shown by the accompanying cut. (See Fig. 35.) They are provided with a pump (2) and an air-chamber (1); the blowpipe (3) is attached to the air-chamber by a ball-and-socket joint, which is readily moved in any direction, and, being self-retentive, leaves the right hand free, which is often a great convenience when it is necessary to add more solder or borax or to guide the solder when its free flowing is retarded by oxidation of the surfaces. The air-chamber may be provided with a plain nozzle, as shown by (3) of the illustration, for the attachment of rubber tubing by which any one of the new forms of hand blowpipes may be substituted for the self-retentive ball-and-socket pipe. (See Figs. 46, 47, 48, showing of automatic blowpipes for crown- and bridge-work and general soldering purposes.)

FIG. 35.

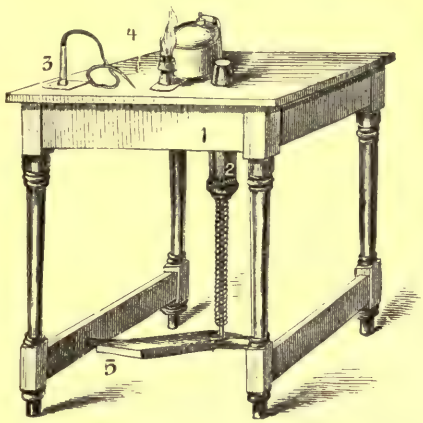
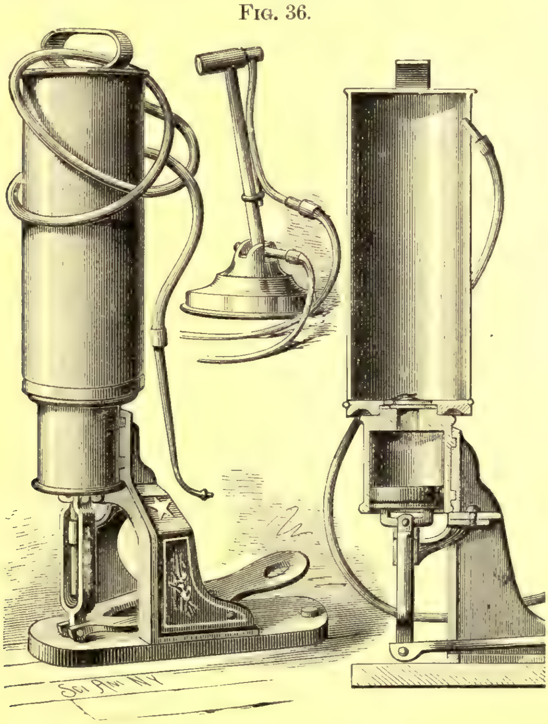


FIG. 36.



The Burgess blowpipe illustrated in Fig. 36 is constructed on the same general principles as the Bishop. It is not attached to a table, but

may be used as an attachment to the soldering table. It is a simple and efficient apparatus for maintaining a continuous supply of air in solder-

Fig. 37.

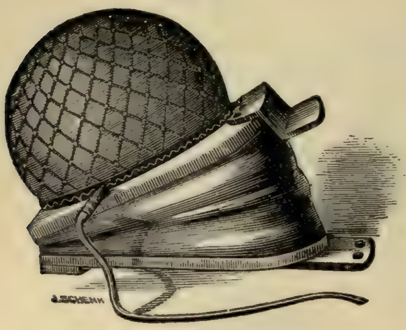


Fig. 38.

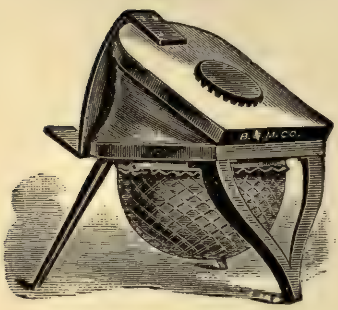
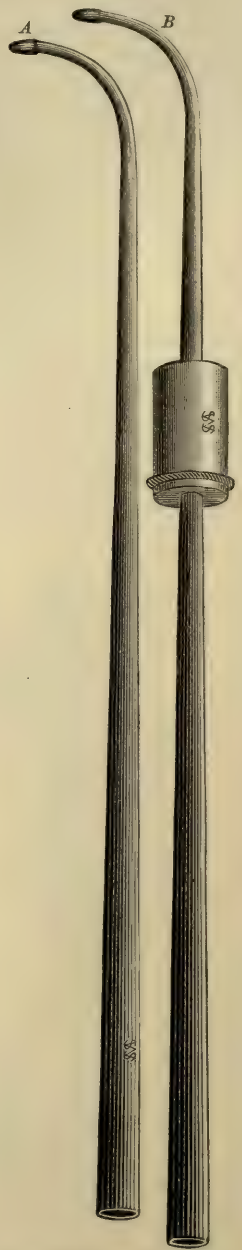


Fig. 39.



Mouth blowpipes (brass).

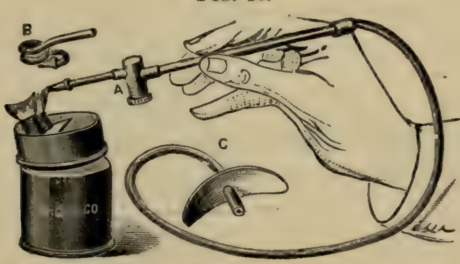
ing, giving a steadier and stronger blast than can be obtained by the use of the ordinary blowpipe. A pressure of from two to twelve pounds is produced at the will of the operator by accelerating the motion of the foot. The machine weighs 12 pounds, and measures 22 inches in height. The pump-cylinder is $2\frac{1}{2}$ inches in diameter, with 3-inch stroke. The internal mechanism is clearly illustrated in Fig. 36.

Mr. Fletcher has devised a foot-blower, shown in Figs. 37, 38, which may be used with any form of blowpipe. The reservoir of the upper portion, which holds the air, is, when the bellows is not in operation, merely a disk of thick coffer-dam rubber, which expands under

the pressure of the air while the bellows is in motion, and thus affords a compact, powerful, and effective arrangement. The step for the foot is very low, and the blower may be used with ease whether the operator is standing or seated. The pressure is steady and equal, and if the rubber disk is distended until forced against the net, it can be increased to almost any extent desired, and will give, if required, a heavy and continuous blast through a pipe of a quarter-inch clear bore.

The mouth blowpipe is an instrument which has long been used by workers in metals for the purpose of soldering together small pieces of metal and for melting and reducing purposes generally. The ordinary form (Fig. 39 *A*) consists of a conical brass tube, from 200 to 240 mm. long, curved at the narrower end to nearly a right angle, so that the flame may be conveniently directed upon the piece of metal to be soldered or melted, as the case may be, which is held upon some suitable support, such as a piece of charcoal, coke, or pumice-stone. When the blowpipe is used in its simplest form, by the mouth, the large end of the instrument is held between the lips and the small end toward the flame. The blast should not be sustained by the respiratory organs, but, in order that an unbroken current may be kept up, the mouth should be filled with air, to be forced through the blowpipe by the muscles of the cheeks. While these are forcing the air through the blowpipe the connection between the chest and the cavity of the mouth should be closed by the palate, which thus performs the part of a valve. The beginner is liable to fall into the error of not closing the connection between the chest and the mouth at the proper instant, and of obtaining the force necessary to propel the air through the blowpipe from the lungs. That this manner of using the instrument may injure the organs of respiration cannot for a moment be doubted, and the operator should early acquire the proper method above described. To avoid tiring the muscles of the lips by long-continued blowing the trumpet mouth-piece has been rec-

Fig. 40.



ommended, and is shown in the annexed cut (Fig. 40). This is merely pressed against the open mouth, and an uninterrupted blast may be kept up for a long time without causing the least fatigue of the orbicularis oris, since, when the trumpet mouth-piece is used, that muscle takes but a passive part in the operation. This trumpet-piece, however, should be so curved as to correspond with the shape of the mouth, otherwise it will require to be pressed very forcibly against the lips in order to prevent the escape of air.

The blowpipe should be constructed of either brass or German silver,

as these alloys are but poor conductors of heat. Silver is not well

Fig. 41.

suited for the purpose, because it transmits temperatures so readily that it soon becomes too hot for the fingers.

A long-continued and steady flame maintained by the mouth blowpipe is apt to cause disturbances in the flame from the collection of moisture in the tube, which is liable to be expelled by the pressure of the air. To avoid this a hollow chamber is constructed about midway in the instrument (Figs. 39 *B*, and 41). The length of the blowpipe should be adapted to the eye of the operator, so that the object upon which the flame is directed may be distinctly seen.

Fig. 42.

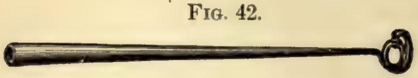


Fig. 43.

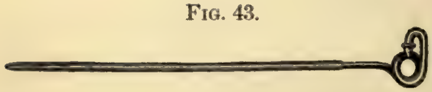


Fig. 44.

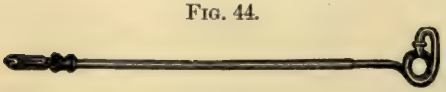
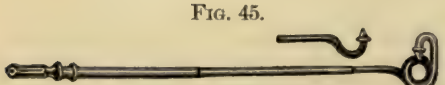


Fig. 45.

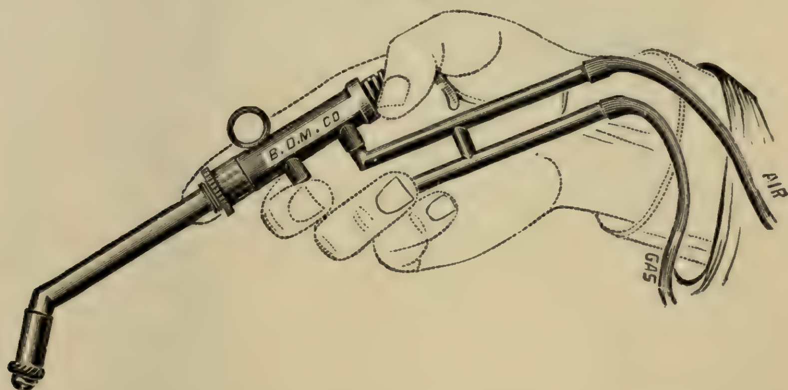


Improvements in these instruments (Figs. 41–45) have been made by Mr. Thomas Fletcher, F. C. S., of Warrington, England, by which temperatures beyond those which can be produced by the ordinary form of blowpipes are attainable. They not only give temperatures never approached by the old blowpipes, but are in every respect more convenient, easier to use, and better adapted for every class of work. With the same amount of blowing as with the common form these blowpipes will do nearly double the work: if high temperatures are not required, the labor of blowing is reduced in proportion. The chief improvement consists in coiling the air-

tube into a light spiral over the point of the jet. This coil takes up the heat which would otherwise be wasted, and utilizes it by heating the air in its passage. The author has found this form of mouth blowpipe to be well adapted for fine analytical operations by cupellation, as well as for all the uses of the dental laboratory.

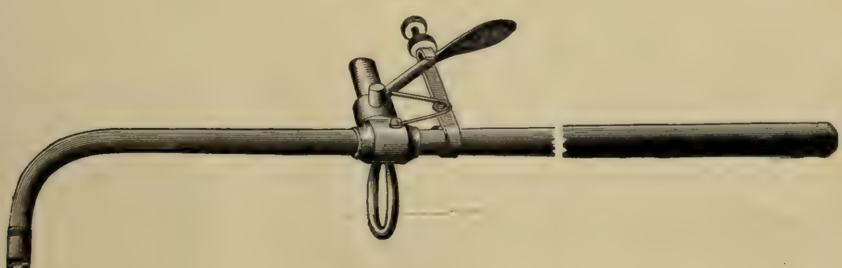
The "automaton blowpipe," a somewhat recent improvement of Mr. Fletcher's intended for general laboratory use, and much employed by

FIG. 46.



experts in crown- and bridge-work where gas is available, has quite superseded the mouth blowpipe in all delicate soldering operations. The blast may be supplied by either the Bishop, Burgess, or Fletcher foot-blower. The supply of gas and air is controlled by a longitudinal movement of the tube, worked by a spring under slight pressure of the hand when it is held as shown in the illustration (Fig. 46). This is

FIG. 47.



sufficient to give either a pointed jet or a full-sized flame at will. The gas-passage does not close entirely, but allows of the escape of enough gas to prevent the flame from going out when the blowpipe is not in use, and it may be hung up by the ring which is attached to it when it is desirable to get it out of the hand.

Dr. Geo. W. Mellott has devised a blowpipe especially for use in crown- and bridge-work, which is in many respects similar to the preceding. The gas is supplied through a valved tube (Fig. 47) by con-

FIG. 48.

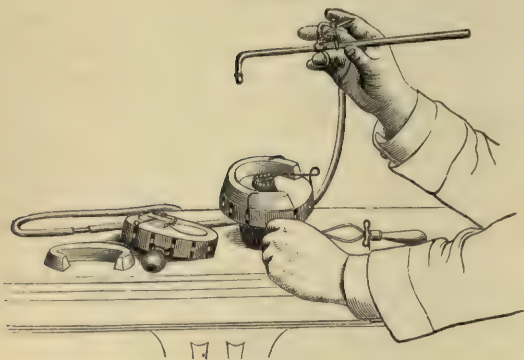
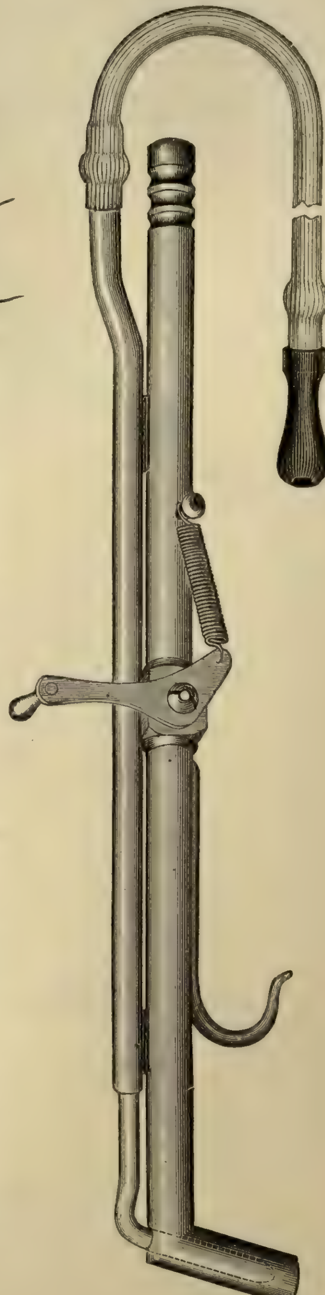


FIG. 49.



Lee blowpipe.

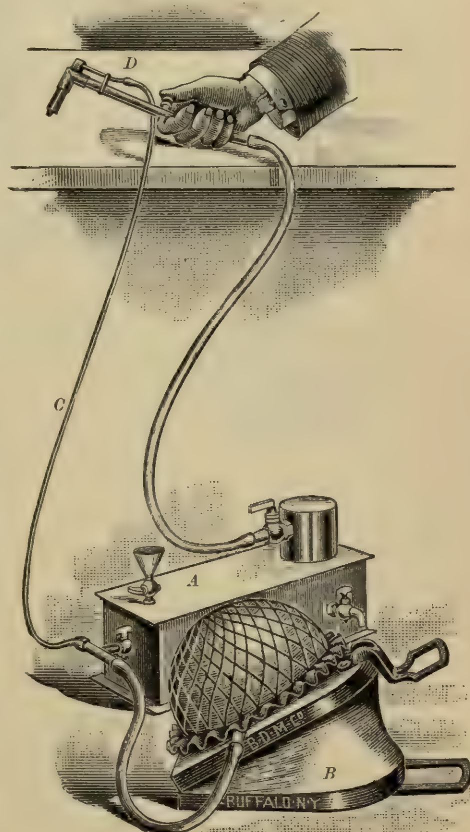
necting it with rubber tubing to a gas-bracket. The spring valve which regulates the supply of gas may be set by means of a thumb-screw and jam-nut to a flame of any desired size. When used as a hand blowpipe the best way to hold it is with the third finger through the ring, as shown in Fig. 48. It can also be used with the foot-bellows when a more powerful blast is required, or with nitrous oxide to procure an oxyhydrogen flame.

The blowpipe designed by Dr. F. H. Lee is shown in the annexed illustration (Fig. 49). It is provided with a mouth-piece with rubber tubing, so that it can be operated by the mouth, or, by removing that attachment, with the foot-blower. The flame is controlled by the spring lever so accurately that a wire flame can be directed upon a particular spot. Releasing the lever shuts off the gas-supply, allowing only enough to escape to keep the flame lighted for future use.

Where gas is not available a simple and perfectly safe blowpipe, made expressly for use with gasoline gas, has been devised which possesses a power and efficiency fully equal to that obtained from coal-gas. As shown in Fig. 50, it is provided with a generator (A) which requires a supply of air under pressure, and is therefore operated in connected with a foot-bellows (B). To charge the generator pour gasoline in the funnel-cock until it overflows at the small tap in the side of the generator near the bottom ; then close the funnel-cock and

also the overflow tap. After charging the generator connect the foot-blower to the "tee" on the end of the generator by a two-foot piece of the large rubber tubing of $\frac{5}{16}$-inch diameter. Cut from the large tubing a 3-inch piece and attach to the other branch of the "tee," having first inserted the large end of the brass reducer in one end of the tubing. Then connect the reducer and air-pipe C to the blowpipe D by means of the small tubing C. The remainder of the large tubing is then attached to the cock on the dome of the generator and to the large end of the hand-piece of the blowpipe.

FIG. 50.



To operate the blowpipe open the cock behind the "tee," and then the cock on the dome; then operate the blower slowly and ignite the vapor at the blowpipe nozzle. The quantity of vapor required is adjusted by the tap behind the "tee" on the end of the generator. The size of the flame is controlled by the thumb-valve on the blowpipe, shown in Fig. 51. A very light pressure of air is required to operate this form of blowpipe.

Different samples of gasoline will often be found to vary in quality. When a few drops of a good quality of this material are poured on a plate, it should evaporate quickly and completely, leaving no greasy residue: 74° to 76° gasoline, such as is commonly used in "vapor stoves" for culinary purposes, is suitable for use in the "gasoline

FIG. 51.

Gasoline blowpipe.

generator and blowpipe." The heavier hydrocarbons or naphthas will not give as good results. It is important that all the tubing used in

connection with this apparatus be kept in good order, otherwise its power may be greatly reduced. If the gasoline is of inferior quality and contains the heavier oils, the generator will not work satisfactorily; it will then require emptying and refilling with a better quality of gasoline. At the conclusion of an operation all taps on the generator should be closed; it can then be left for any length of time ready for instant use.

Fig. 52.

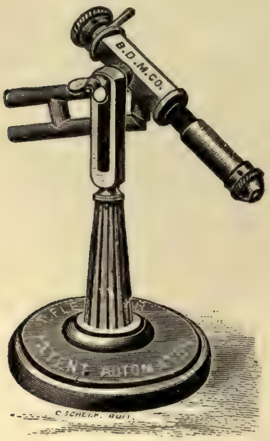
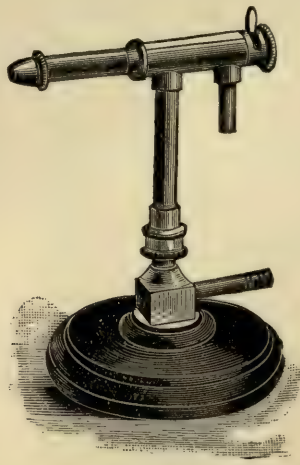


Fig. 53.

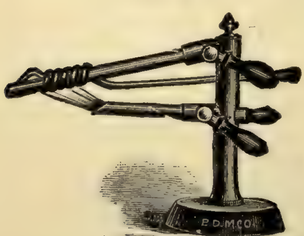


Automatic blowpipe.

There are other forms of automatic blowpipes (Figs. 52–54), which are mounted on iron bases and provided with a ball-joint, so as to be self-retentive and adjustable at the will of the operator.

The hot-blast blowpipe devised by Mr. Fletcher, shown in Figs. 54 and 55, possesses a power but little inferior to the oxyhydrogen blowpipe. It fuses pure gold without difficulty, and is therefore of great value as a soldering appliance in continuous-gum work, where gold in its unalloyed state is used as the solder. The use of a powerful blowpipe is undoubtedly a safer means of soldering the teeth to the plate in this class of dentures than is the other plan of completing that part of the work in the muffle of a furnace, for by the latter means the danger of "etching" the teeth is greatly increased, as the teeth are necessarily brought to the maximum temperature; whereas by the use of a blowpipe, the piece having first been thoroughly dried and heated to a point considerably below the fusing-point of gold, the flowing of the solder is accomplished by concentrating the heat upon the points to be united, while the asbestos and plaster investment protects the porcelain teeth from a very high degree of heat. In this instrument the air-pipe, as will be seen, is coiled around the gas-pipe, and both are heated by three small Bunsen burners, the gas-supply to which is controlled by a separate stopcock. The air-blast is obtained

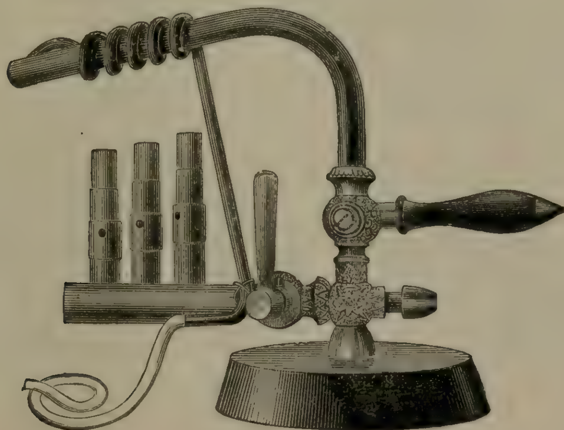
Fig. 54.



by a foot-blower connected with the blowpipe by means of a flexible rubber tube. (See Fig. 55.)

Wherever gas can be obtained it furnishes at once the best and

FIG. 55.

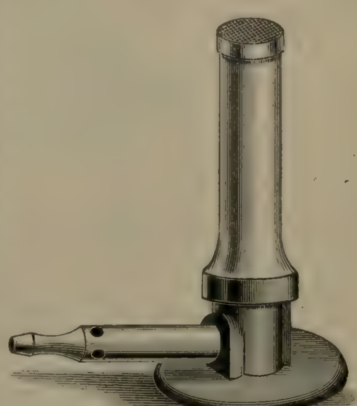


Hot-blast blowpipe.

most economical, as well as safest, fuel for blowpipe work. Those who prefer the detached flame and simple form of blowpipe, which may be used either by the mouth or foot-blower, to the more recent compound apparatus of Mr. Fletcher, may readily construct a burner which will be found to answer every requirement of the laboratory by attaching to the base of an ordinary Bunsen burner, which may be obtained at the dental dépôts (see Fig. 57), a piece of brass tubing 6 inches in length by $1\frac{1}{4}$ inches in diameter. Over the top of this, in order to properly spread the flame, a piece of fine brass-wire gauze is fastened by means of a ring of sheet brass $\frac{1}{4}$ of an inch in width. Connection may be made with the gas-bracket in almost any part of the room by means of flexible rubber tubing.

FIG. 56.

FIG. 57.



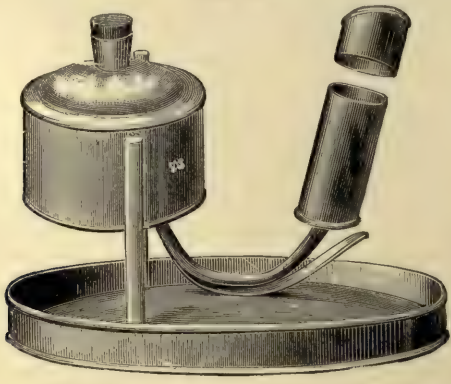
Another form of heating apparatus, designed for soldering with the ordinary simple blowpipe and for other laboratory uses, is represented in Fig. 56. It is known as the "duplex burner." In addition to the usual Bunsen burner, a larger flame for soldering purposes can be obtained by

rotating the upper portion upon the base. A small jet, when once lighted, ignites either flame, so that it is always ready for use. When used, however, for all kinds of soldering operations, large and small, this burner is inferior to the one previously described.

In villages and small country places gas is not always available, and it may therefore become necessary for the dentist to use a soldering lamp burning alcohol, kerosene, or gasoline. Of the three, the latter is probably preferable since the introduction of Mr. Fletcher's admirable gasoline generator and blowpipe, *but this agent cannot be used with safety in an ordinary lamp.*

When either alcohol or kerosene is employed, it is of the greatest importance that a lamp designed to meet the practical requirements, and also with a view to safety be selected. The first essential is to have the wick large enough to afford a flame of sufficient magnitude to enable the operator to solder an entire artificial denture or to fuse from one to two ounces of gold. This would require a wick at least $1\frac{1}{4}$ inches in diameter and about 3 inches long. Its connection with the reservoir or body of the lamp, which should have a capacity of not less than 1 pint, in which the combustible fluid is contained, should not be direct nor in such close proximity that explosive gas would be likely to form. The "Franklin safety lamp," a cut of which is annexed (Fig. 58), will be

Fig. 58.



found to answer every requirement. It consists of a reservior 5 inches in diameter by $2\frac{1}{2}$ inches deep. The wick-holder, 3 inches long by $1\frac{1}{2}$ inches in diameter, is connected with the reservoir by a curved tube 5 inches long by $\frac{3}{16}$ of an inch in diameter. Thus a sufficient quantity of the burning fluid is supplied to the wick to afford a constant flame, while there is very little danger of the heat from the wick-holder being conducted to the reservoir. The author has found that most of the explosions during soldering operations which have come under his notice were due to the case-heater—or soldering-pan, as it is more commonly called—filled with live coals, being held for a long time so close to the lamp that inflammable gases were generated and ignited from the wick, when an explosion of more or less violence inevitably followed. The Franklin safety lamp is constructed upon correct principles, as is also the lamp represented in Fig. 59, but such forms of lamps

as are shown in Fig. 60 should always be avoided, except for use with non-explosive oils.

Supports.—In melting small quantities of gold or silver or in soldering with the blowpipe flame it is necessary to perform these operations upon a support made of some suitable body, such as charcoal, coke, pumice-stone, or asbestos and plaster, charcoal and plaster, etc.

Well-burned charcoal is especially suited for both purposes, as it helps to increase the heat, and in the putting together of small quantities of

FIG. 59.

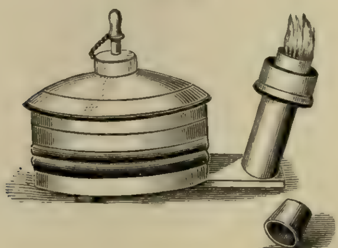
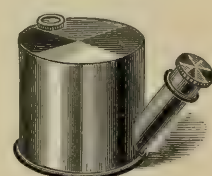


FIG. 60.



gold or silver solders prevents oxidation of the base metals which are added to reduce the fusing-point of the alloy and cause it to flow freely. Charcoal made from the light woods, such as pine, is best, because it is not so likely to throw sparks when the flame is directed upon it as are the harder coals, such as that made from oak; and, being softer, it is much better adapted to soldering operations in which it is necessary to hold the pieces to be united together by means of small nails or tacks thrust into the support; as, for instance, where a rim is to be soldered to a plate, the former must be brought in contact with the latter upon the charcoal, and so held during the preliminary soldering, which consists of uniting the rim to the plate with a small piece of solder at some one point, after which the accurate adjustment of the rim to the plate for final soldering is rendered much easier.

A good solid piece of charcoal, sufficiently large, should be selected, and bound with iron or copper wire to prevent its breaking into pieces. It should then receive a coating of plaster, from a quarter to a half inch in thickness, on all sides except the one upon which the object to be soldered is to rest. This adds to its strength and prevents the fingers from being soiled in handling it. Good charcoal, suitable for use in the dental laboratory, cannot, however, always be found when wanted, and it is therefore often necessary to use some other substance which may be more easily obtained. Thus those living in large cities may be compelled to employ pieces of coke as support in soldering. Next to charcoal, coke is most suitable for that purpose. It is more durable than charcoal, and when such a support, composed of one large piece or even several smaller pieces, is bound together with wire and coated with plaster, it will last a long time. Large pieces of pumice-stone also answer well for the purpose of holding small objects while the flame of the blowpipe is directed upon them. Neither of these, however, is so well adapted as charcoal for holders when small quantities of metals are to be melted, in consequence of their greater porosity and hardness,

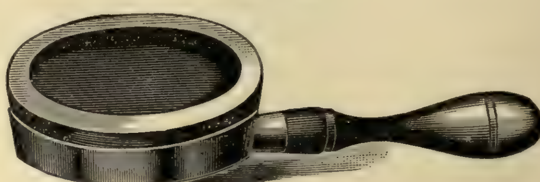
which prevent the cutting of suitable pits for the reception of the metal to be fused.

A very good support for soldering purposes alone may be formed by filling a cup made of sheet iron or copper, 5 inches in diameter by 5 inches in depth, with a mixture of asbestos and plaster or plaster and finely-broken charcoal. The vessel should be supplied with a wooden handle, fastened in the bottom, for convenience in handling.

Plattner's *Manual of Qualitative and Quantitative Analysis with the Blowpipe*, p. 15, gives a method of artificially preparing good solid supports of charcoal which might be found of value in the dental laboratory. It consists of mixing charcoal-dust (which must not be too finely ground) with starch paste. The latter is prepared by combining 1 part of starch with 6 parts of boiling water. These are stirred in an earthen pot until all the meal is converted into paste. This paste is rubbed in a porcelain mortar with frequent additions of charcoal-dust until the mass becomes too tough for further admixture, when enough of the coal-dust is kneaded in with the hands to render the whole mass stiff and plastic. From this the desired forms of supports can be made, allowed to dry gradually and thoroughly, and then heated to redness in a covered vessel, so as to char the starch paste. The charring may be regarded as complete when the evolution of gases from the mass ceases or when it

Fig. 61.

Fig. 62.



has been heated to dull redness. Coals thus formed are of the proper firmness, and ring like ordinary good charcoal when thrown on the table.

Blocks formed of graphite and fire-clay are now often used as supports for holding objects to be soldered. These are by no means perfect

Fig. 63.

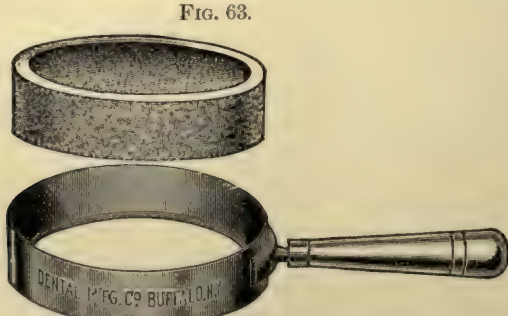
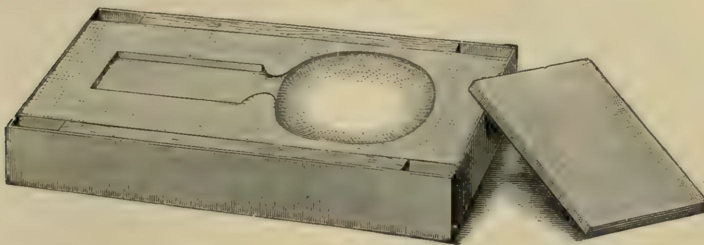


Fig. 64.

non-conductors, and when used without some protection to the hand they soon become so hot in the operation of soldering that it is impos-

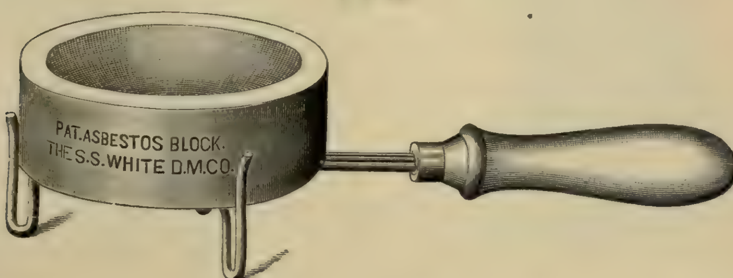
sible to hold one for any length of time. To overcome this difficulty, however, a very convenient device for holding the carbon, graphite, or other support has been introduced. (See Figs. 61 to 63.)

FIG. 65.



Soldering blocks have recently been formed of asbestos, and have found favor with many in preference to the "carbon block" for solder-

FIG. 66.



ing purposes. They are circular, depressed on each face, and 4 inches in diameter.

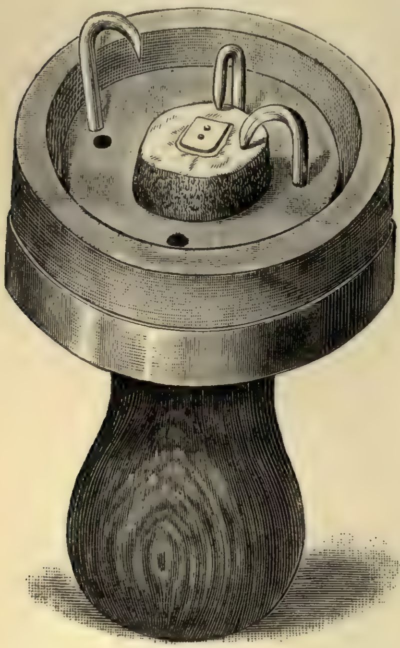
The carbon cylinder, made of the same composition as the carbon block, is a new form of support admirably adapted for soldering small articles, such as gold crowns, or for blowpipe assays. In size it is $1\frac{1}{8}$ inches in diameter by 3 inches in length (Fig. 64).

Amongst the more recently introduced forms of asbestos soldering and melting supports are those shown in the annexed illustrations. Fig. 65 represents a combined soldering, melting, and ingot block, 6 inches long, $2\frac{1}{2}$ inches wide, by $\frac{1}{2}$ an inch in thickness. Fig. 66 shows an asbestos support intended exclusively for soldering, $4\frac{1}{2}$ inches in diameter by $1\frac{3}{4}$ inches high, with concave top, and provided with a convenient holder, which also prevents the support from being laid flat upon the table while hot. Fig. 67 shows an asbestos soldering tray which is particularly useful in soldering crown- and bridge-work. It has a raised rim set in a brass box mounted on a wooden handle, the end of which is flat, so that the appliance can be held in the hand or set upright on the work-bench. Four holes are drilled in the bottom for the reception of brass pins to hold the work in place.

When the object to be soldered is an artificial denture containing a number of teeth, a support that will be found to answer all requirements is the hand-furnace, such as is now furnished by the dental dépôts (Fig.

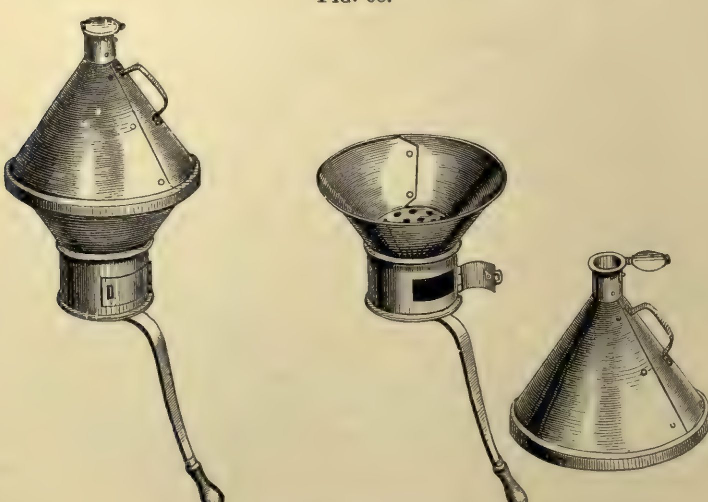
68). It consists of a funnel-shaped receptacle of sheet iron, with a grate or perforated plate near the bottom, and a small door on one side underneath the grate for the admission of air. The upper part of the holder is surmounted by a cone-shaped top; to the bottom is attached an iron rod, six or eight inches long, terminating in a wooden handle. This apparatus is designed to serve both the purpose of heating the case and as a support or holder during the soldering. For the first it is not well suited, being too small to contain fuel enough to admit of a thorough heating of the invested denture; but when the object has been brought to the proper temperature it makes an admirable holder for a set of teeth while the flame of the blowpipe is being directed upon it.

Fig. 67.



The best method of "heating up" a denture preparatory to soldering is to place it on a gas-oven, such as is employed in the dental laboratory for general use and for heating flasks in packing rubber work, etc. (Fig. 69). A ring of cast or sheet iron, 6 inches in diameter by 2 inches high, should then

Fig. 68.



Soldering furnace.

be placed around it for the purpose of holding the charcoal, which, in

pieces the size of a hen's egg, should be built around the outside of the denture so that it may be uniformly heated. The cone or top of the

FIG. 69.

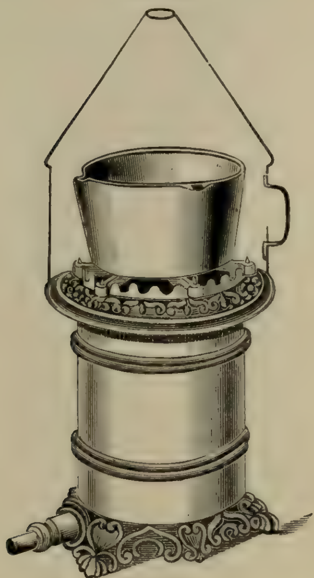
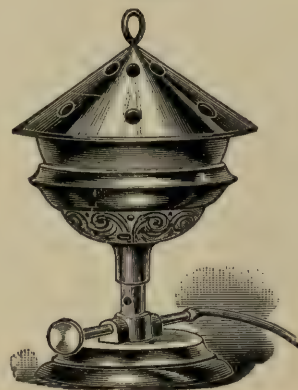
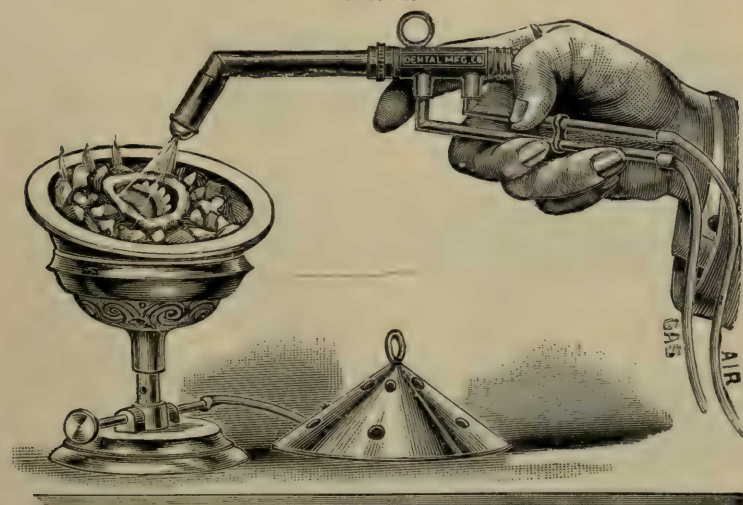


FIG. 70.



apparatus just described may now be placed over it. The gas is then lighted, but the full head should not be turned on until the moisture of

FIG. 71.



the investment has been driven off, when it may be gradually increased until the piece is heated to redness. About thirty minutes will be

required to reach the proper temperature for soldering, when the piece may be lifted from the gas-oven with suitable tongs and placed in the hand furnace. The live coals used in heating up should also be placed around the outside of the investment to prevent the too rapid cooling of the piece should any delay in the soldering occur. When the latter operation has been satisfactorily completed, the top may be placed tightly on and all access of air excluded, in order that the piece may cool slowly and thus avoid the danger of cracking the teeth.

The "Lewis" combined case-heater and soldering-cap (Fig. 71) is a recently improved device for drying out and soldering an investment of gold work without removing until completed. It consists of an iron cup or hemisphere, with suitable openings for the admission of heat from below, supported by another iron cup attached to an improved Bunsen burner and rotating on it. The upper hemisphere is capable of being swivelled or tilted in any position desired to facilitate the flowing of the solder and to bring all parts under the action of the blowpipe.

The cup is filled with pieces of broken pumice or coils of asbestos rope, upon which the case rests. To dry out an invested denture it is arranged in the cup, the burner lighted, and the cover placed on to retain the heat. After thoroughly drying, which should be preliminary to the final heating, the temperature should be raised by increasing the flow of gas until the whole piece has assumed a dull-red appearance, when the top cover may be removed, the cup tilted to a convenient position, the blowpipe brought into use, and the soldering finished. The burner underneath should remain lighted during the entire operation. The position or angle of the cup may be changed by a slight pressure with the blowpipe on its flanged edge.

FIG. 72.

FIG. 73.

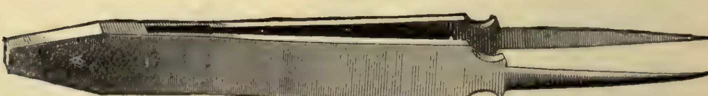
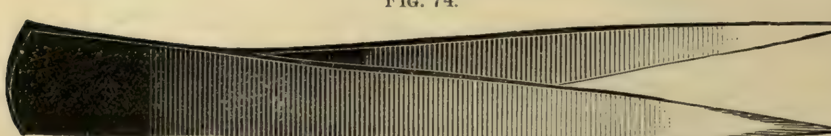


FIG. 74.



Suitable solder tweezers, designed respectively for placing pieces of solder upon parts to be united and for holding gold crowns or other small articles while soldering, are important accessories of the soldering-

table. Figs. 72–74 show the ordinary forms of the first, and Figs. 75–78 those more recently designed particularly for use as holders in the construction of metallic caps and crowns.

Fig. 75.

Round point.

Fig. 76.

Angular point.

Fig. 77.

Flat point.

Fig. 78.

Hawk bill.

Wire clamps are indispensable in a certain class of soldering operations, and a small collection of different sizes of such forms as are shown in Fig. 79, made of No. 16 iron wire, should always be kept on hand ready for use. The smaller clamps shown in the illustration are especially useful in the construction of lower metallic plates. When two thin pieces have been swaged separately with a view to uniting them by

soldering, there is always danger of their being forced apart by the calcination of the borax which is present as a flux, and by expansion when the heat is applied: it is necessary, therefore, to hold them together temporarily until the preliminary or partial soldering is accomplished.

FIG. 79.

In soldering a chamber cap to an upper plate the cap is almost certain to change its relation to the plate during the soldering unless secured *in sitû* by a stout wire clamp. For this purpose it is well to have on hand a few different sizes of the larger clamp shown in Fig. 79.

FIG. 80.

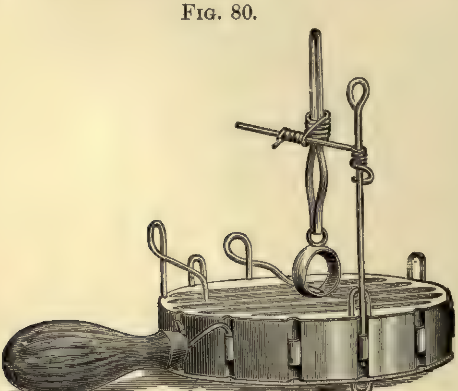


FIG. 81.

FIG. 82.

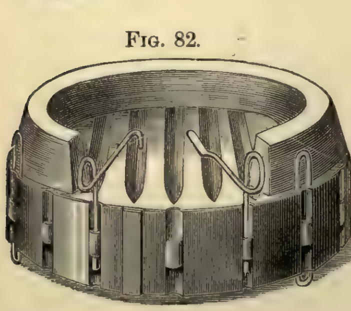
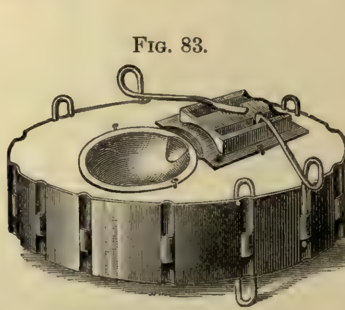


FIG. 83.



Dr. George W. Mellott has devised a soldering appliance for use in crown- and bridge-work. It consists of a support made of wound asbestos tape surrounded by a metal band (Fig. 80), supplied with loops at regular distances apart for the reception of the handle-

hooks or spring-clamps. The support is grooved, so that the heat can pass under the piece, and thus heat it from the bottom as well as the top. The asbestos support is about 4½ inches in diameter. The construction of the support, which is reversible, makes it a perfect cushion into which pins can be readily thrust to hold small articles while being soldered. One face is grooved for soldering; the other has a depression for a melting-cup in which small quantities of gold scraps may be fused. Adjustable feet permit the support to be set up away from the table when desired. Fig. 80 shows the support with clamps and ring-holding device in position; Fig. 82, the grooved face with the removable rim (also of asbestos) for confining the heat; and Fig. 83, the reverse face with cup and ingot-mould attached. The ingot-mould has three matrices of different shapes and sizes. Fig. 81 shows the handle separately.

FIG. 84.

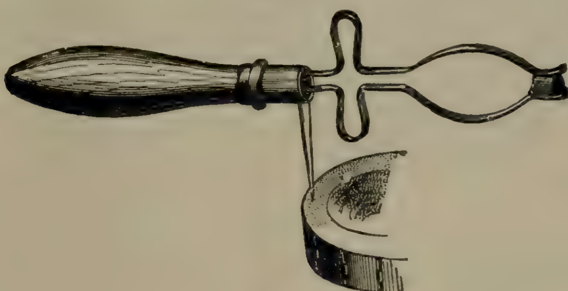


FIG. 85.

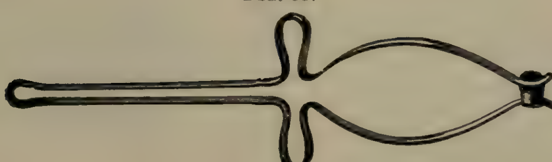
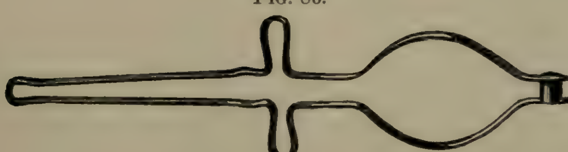


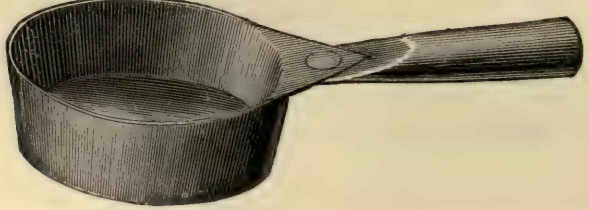
FIG. 86.



The soldering clamps, for holding gold collar crowns and caps while being soldered, have loops in the arms. These loops facilitate placing the clamps in, and removing them from the handle, and afford a ready means of rotating or changing the position of the work under the blow-pipe flame. The slight pressure required to hold the work is secured by pushing the shanks into the handle, the spear of which may then be fixed in the asbestos support or any other suitable support. The left hand by this means remains free to manipulate the solder, while the blow-pipe is directed by the right hand as usual. The handle will receive

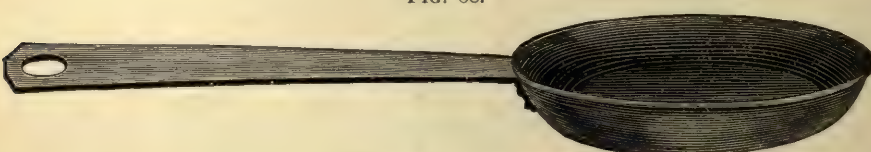
either clamp-shank. The three forms, with the spurred handle, are shown in Figs. 84–86. After removing the investing materials from around the soldered dentures—which, however, should never be done if porcelain teeth are present until the case has been allowed to cool slowly and perfectly—it may be placed in a pickling solution composed of sulphuric acid 1 part, water 4 parts, for the purpose of dissolving the fused borax and the oxide of copper which darkens the surface of gold or silver into which it usually enters as an alloy. Dilute sulphuric acid will dissolve both at ordinary temperatures, but its action may be greatly hastened by heating it to 212° F. This may be done in a copper pickling-pan, such as is sold at the dental dépôts for the purpose (see Figs. 87, 88), or in a Wedgwood evaporating dish, similar to those used by

FIG. 87.



chemists. Sulphuric acid is corrosive and destructive to the clothing; hence ordinary glass vessels are not safe in which to heat the solution, on account of their liability to fracture, and porcelain ware of the quality

FIG. 88.



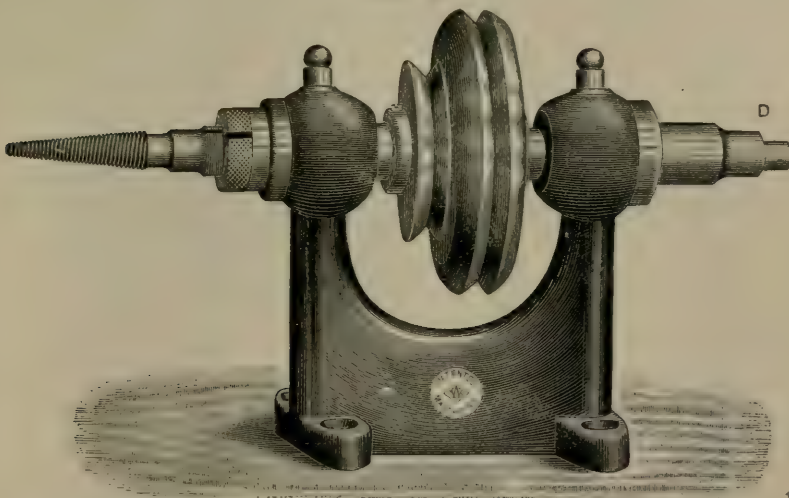
usually made for domestic use will not retain the acid, which soon dissolves the glazing from the surface, after which it is liable to escape through the bottom of the vessel.

A strong solution of common alum may be used instead of the acid, but it requires a temperature of not less than 212° F. to develop its solvent properties.

When the same pickling solution has been used a number of times it becomes quite green in color and crystals of sulphate of copper ($CuSO_4$) form around the edge of the pan. These are the result of the action of the acid upon the oxide, and they redissolve when the solution is again heated. The sulphate is decomposed by electrolysis, and more or less metallic copper is probably always deposited upon the plate, and remains under the teeth in inaccessible places after the denture is finished; hence the "coppery" taste sometimes complained of in newly-soldered dentures when first inserted. This may be remedied in the case of a gold denture by immersion in a weak solution of nitric acid and water; and if the denture is of silver—which metal would be acted upon by nitric acid—boiling in a strong solution of alum is recommended.

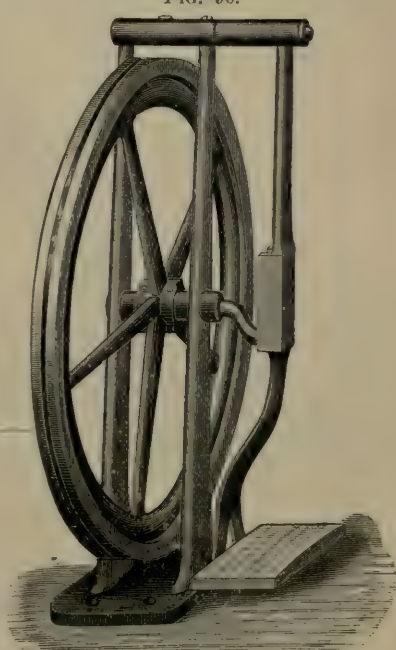
Lathes.—For grinding and fitting teeth a light, easy-running lathe, with a substantial frame of iron or wood 2 feet 11 inches high to the

Fig. 89.



centre of the pulley-head, which will permit the operator to sit while at work, should be provided. The sitting position saves him from much of the fatigue occasioned by continuous work of this kind, while it affords the steadiness to the body and hands which is demanded by the delicate and precise work of fitting teeth to gold or silver plates and to each other.

Fig. 90.

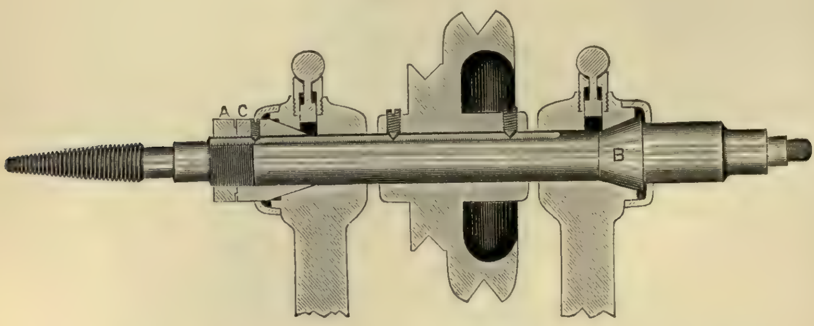


The centre of the pulley-head should be not less than 6 inches from the top of the lathe table, which should be formed of ash or cherry wood 26 inches long by 20 inches wide and $1\frac{5}{8}$ inches thick. The frame may be made of oak or ash wood securely fastened together, or a lathe table similar to the one shown in the illustration (Fig. 94) furnished by the dental dépôts may be employed. The latter, when supplied with a Lawrence lathe-head and driving wheel, forms an excellent lathe.

Many of the lathes now offered for sale at the dental dépôts are not entirely satisfactory either for fitting teeth or polishing. Their driving wheels are either too heavy or too light. Valuable improvements have,

however, been made recently. Figs. 89, 90 illustrate a lathe of recent introduction which will doubtless answer all requirements of the dental laboratory. Fig. 91 shows a sectional view of the lathe-head; Fig. 92

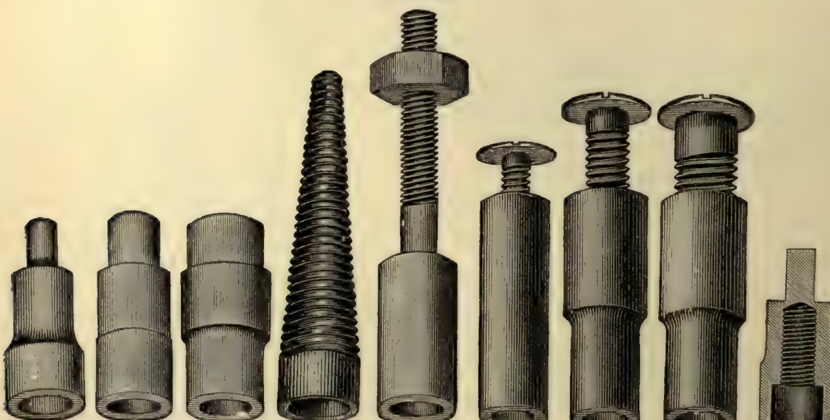
FIG. 91.



a set of chucks for mounting corundum wheels and polishing brushes, etc.; Fig. 93 a reamer for fitting wheels having wooden centres to taper screw-chucks.

A lathe intended for fitting teeth does not require great speed or much power. A good lathe may be made by obtaining the frame and driving wheel of one of the inexpensive form of amateur turning lathes now in the market, and adjusting a Lawrence head to it. The working

FIG. 92.



parts of the lathe should be kept clean, well oiled, and protected as far as possible from abrading powders and others gritty particles with which it is constantly surrounded. In perhaps the majority of dental laboratories but one lathe is used for all purposes of grinding and polishing. It is much better, however, to have a larger and stronger lathe for polishing purposes exclusively, and, as greater speed is required for this purpose, it should be about 3 feet 10 inches in height to the centre of the pulley-head, so that the operator may stand while using it: the form of

lathe-head shown by Fig. 95 will answer admirably. The fly wheel

FIG. 93.

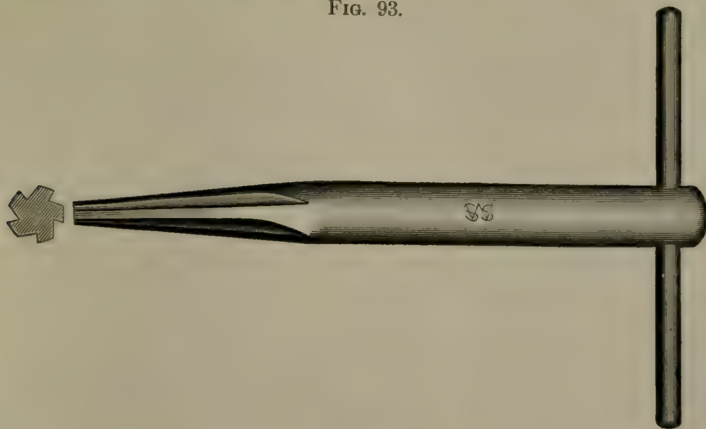
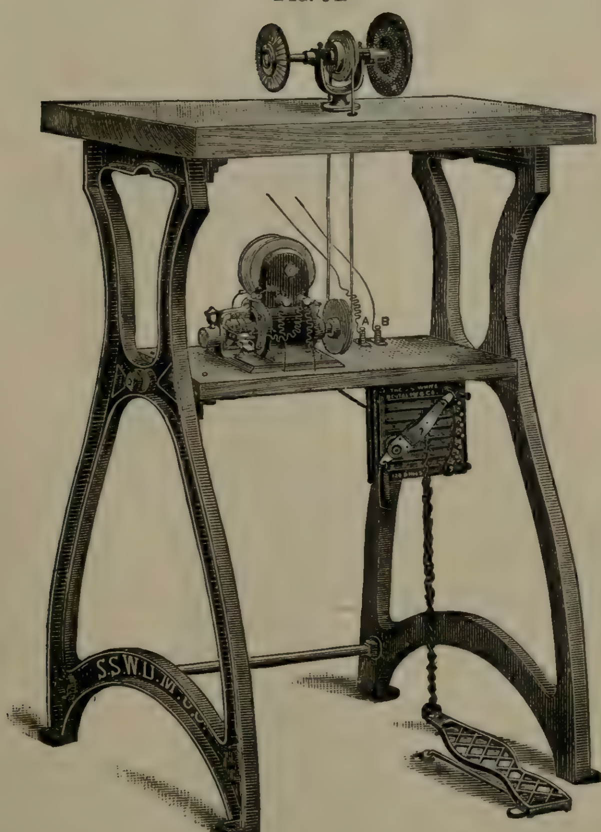


FIG. 94.

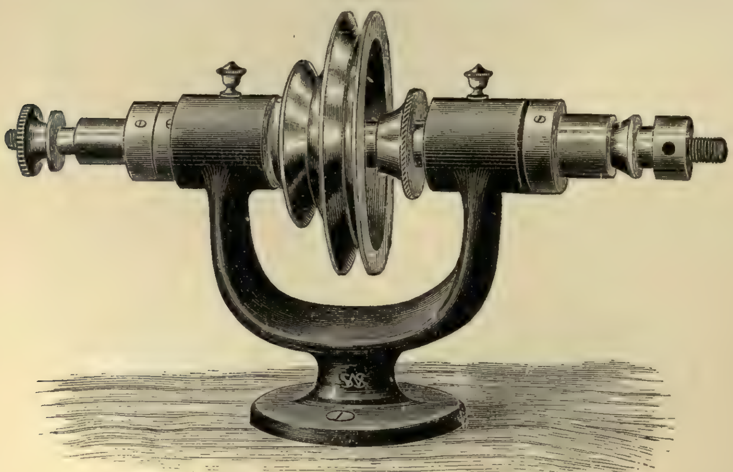


should be at least 20 inches in diameter, and should weigh about 35 pounds. The treadle should be operated by a lever or leg motion, and

not by what is known as the heel-and-toe treadle, which does not afford sufficient speed or power. The lift of the treadle should be not less than $2\frac{1}{2}$ inches.

One of the most valuable applications of electricity to the needs of the dentist is in the running of laboratory lathes, and when supplied with the 110-volt incandescent current such an apparatus is by far the most convenient and effective lathe that is used for the purpose of fitting teeth or polishing dentures. As shown by Fig. 94 it is provided with a one-eighth horse-power motor (C). A variable resistance (D) is inter-

FIG. 95.



posed to permit the lathe to be run at different speeds, the resistance being operated by a foot-pedal: almost any desired speed can be had at will by varying the pressure on the pedal.

The polishing lathe should be provided with a drawer for the safe keeping of mandrels, brush wheels, felt and cotton wheels, cones, etc., together with the abrading and polishing powders which are usually employed in the final finishing of the different kinds of laboratory work. Corundum wheels, spatulas, cements, etc., used in fitting and attaching teeth to the plate, should be kept in a drawer attached to the grinding and fitting lathe.

The corundum wheels so extensively used in the dental laboratory are made of the mineral corundum found in Ceylon and in Pennsylvania, Georgia, Massachusetts, and North Carolina. It occurs in crystals of the form of double six-sided cones of various sizes, and in some localities in large masses without crystalline form. Corundum is an aluminum oxide having the formula Al_2O_3. The ruby and sapphire are transparent varieties of this mineral, their color being due to the presence of a small amount of coloring oxides. Emery, the use of which preceded corundum as an abrasive agent in the dental laboratory, is a coarse variety of corundum. Corundum is, with the single exception of the diamond, the hardest mineral known. It is prepared by pulverizing the crystals in an iron mortar by successive blows of a heavy steel pestle.

The three grits which are employed in making wheels for dental purposes are obtained by passing the powdered corundum through sieves of different degrees of fineness; they are known as fine, medium, and coarse. The latter will cut most rapidly; the finest will not cut so fast, but will leave a much finer surface. The powdered corundum is mixed with finely-ground gum shellac in the proportions of 3 ounces of corundum to 1 of shellac; this is carefully heated and thoroughly mixed until it becomes of a doughy consistence, when it is put into an iron mould made in two parts, previously oiled. This mould is placed in a small press and force enough applied to consolidate and distribute the mixture into all parts of the mould. Too much force should be avoided, as it is liable to drive out so much of the shellac that the particles of corundum will not be sufficiently adherent—a condition which will greatly lessen the wearing qualities of the wheel. After the wheel has been removed from the mould, which is done by tapping the latter sharply with a wooden mallet, it is washed in alcohol for the purpose of removing the shellac from the surface and leaving the wheel in a sharp or gritty condition.

While grinding porcelain teeth the corundum wheel must be kept constantly wet to prevent the shellac from becoming heated by friction—a condition which instantly impairs its cutting properties. Numerous appliances have been devised in the form of "drip cups" designed to automatically supply sufficient water to the wheel while in use to prevent heating; but these are objectionable in more than one respect, and are liable to obstruct the light and prevent it from falling directly upon the point of contact of the tooth with the wheel. A simple dish, oblong in form, with the dimensions of 8 inches in length by 5 inches wide, by $2\frac{1}{2}$ in depth, partially filled with clean water, serves as a good hand-rest, while a piece of sponge of the size of a large walnut, which the operator will soon acquire the habit of holding between the index and middle finger of the right hand while he keeps it in contact with the corundum wheel, is an excellent means of conveying water to the wheel and preventing it from splashing his face or clothing.

There are at least seven sizes of corundum wheels made for dental-laboratory purposes, ranging from $\frac{3}{4}$ of an inch in diameter to $2\frac{1}{8}$ inches, but the author has found, after much experience in fitting carved blocks, rubber sections, and single gum teeth, that a maximum of 1 inch in diameter and $\frac{1}{6}$th of an inch in thickness is quite large enough for jointing purposes, while the smaller sizes, which are indispensable, are obtained by the wearing away of the 1-inch wheels.

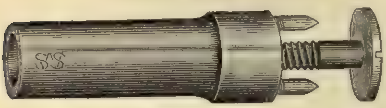
In finishing dentures the first step is the proper levelling of the surface: this is usually done in metallic cases with the corundum wheel, after which the scratches left by the sharp particles of corundum should be removed by a keen-edged vulcanite scraper. The piece is then ready for the "Scotch stone," a soft mottled stone much used by silversmiths and workers in the precious metals, furnished by the dental supply-houses in pieces of 6 inches in length by $\frac{1}{4}$ inch in thickness. This material has decided abrasive qualities, and is used chiefly to remove the scratches left by the corundum wheel and scraper: it produces a fine silk-like surface and brings the case to the point where the buff wheels armed with the coarser powders, such as pumice, are to be used: these produce a surface which may be highly polished by the brushes which

should follow the buff wheels, and should carry the finer polishing powders or those used for the purpose of obtaining high lustre, such as calcined buckhorn when the case is of gold or silver, and prepared chalk when it is of vulcanite or celluloid.

In vulcanite or celluloid work the corundum wheel need not be used, the scraper being sufficient for the levelling of the surface, after which the finer numbers of emery paper, Nos. 0 and $\frac{1}{2}$, are employed, until all traces of the scraper are removed, when it is ready for the pumice powder, which is generally applied with a small stick of soft wood, such as poplar or pine, after which the denture is ready for the felt or other kind of buff-wheel and fine pumice.

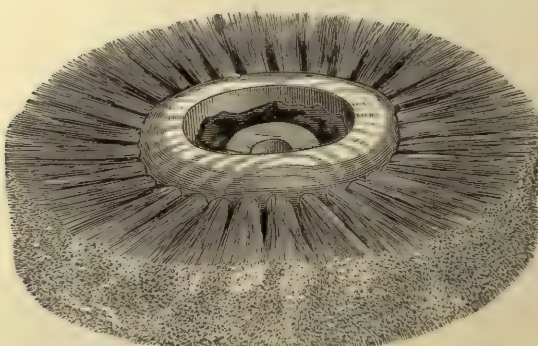
Buff-wheels and cones are made of felt, cotton duck, leather, soft wood, cork, disks of cloth or chamois leather, stitched together, etc. Felt is probably the best of the various materials used in forming buff-wheels: these wheels can be obtained at the dental dépôts in sizes ranging from $1\frac{1}{8}$ to $2\frac{1}{2}$ inches in diameter. Buff-wheels are intended to cut and not to polish. They are usually armed with pumice, and must be kept constantly wet while in use. The best size of buff-wheel for dental-laboratory use is $1\frac{5}{8}$ inches in diameter by $\frac{3}{8}$ of an inch in thickness. Smaller sizes are obtained by the wearing away of the larger wheels. They are easily mounted upon the "screw-cone" mandrel, to which they do not ordinarily require to be cemented or shellacked. An ingenious felt-wheel chuck has been suggested by Dr. F. E. Pomroy: it is provided with three steel pins to prevent the wheel from revolving on the screw (Fig. 96).

FIG. 96.



Felt-wheel chuck.

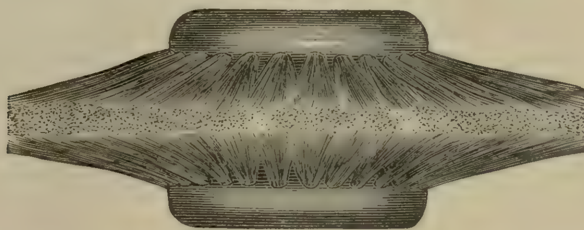
FIG. 97.



The brush-wheel is employed for the purpose of obtaining a still finer surface than is attainable with the Scotch stone or buff-wheel and for the final polishing. There is quite a variety of forms made for dental-laboratory use, beginning with the wood-centre brush-wheel with straight bristles in from one to four rows (Fig. 97); the brush wheel with converging bristles (Fig. 98); the cup-shaped wheel with from one to four rows of bristles (Fig. 99); cup-shaped bristles with long wooden shanks;

hub-shaped with straight bristles and hub-shaped with converging bristles, etc. In selecting brushes it should be remembered that those with coarse bristles are to be employed with abrading powders of the class to which pumice belongs, while those with soft bristles are particularly

FIG. 98.



adapted for use with prepared chalk, rouge, calcined buckhorn, etc., or wherever a high lustre is to be attained. Two brushes of each of the Nos. 1, 2, and 3, one coarse and the other soft, with three rows of bristles, are sufficient for finishing entire or partial dentures, with the addition of

FIG. 99.

two small straight brush-wheels of $1\frac{1}{2}$ inches in diameter, with two rows of bristles, for finishing places in the denture which will be found inaccessible to the larger wheels and for polishing crown- and bridge-work.

Finishing powders are divided into two classes, used under different conditions and serving different purposes. The following partial list gives a few of those in general use:

Cutting powders :	Pumice, Emery, Corundum flour, Arkansas powder, Hindostan-stone powder, Tripoli,	used with a lubricant.
Polishing powders :	Calcined buckhorn, Rotten-stone, Prepared chalk, Rouge,	used comparatively dry.

Emery with oil has long been used by workers in the precious metals for cutting down the surface of gold and silver preparatory to the final

polishing, but, as it is nearly black and liable to discolor the joints of the teeth, it is an objectionable mixture to employ in the finishing of artificial dentures; hence its place has almost entirely been taken by pumice powder, with Castile soap and water as the lubricant. Emery is perhaps better suited for finishing continuous-gum cases, which, having no joints, are not liable to the same danger of discoloration as are dentures formed of single gum teeth; platinum, of which the plates of this kind of dentures are made, resists attrition to a greater extent than does gold or silver: it therefore requires a more decidedly abrasive powder than would suffice for either of those metals to produce smoothness enough for the final polishing.

Of the polishing powders properly so called, calcined buckhorn has been found of so much value as an agent in the production of high lustre in gold and silver work, that it has almost entirely superseded the use of the burnisher. It is applied with a soft bristle brush-wheel, similar to Fig. 99, revolving at the highest speed attainable. The powder is at first slightly moistened with water, but as the lustre appears it is taken up between the tips of the fingers and dropped in a perfectly dry condition upon the plate.

Rotten-stone is also an excellent polishing powder, but, like emery, it is liable to discolor the joints and to find its way behind the backings in soldered work, and effect more or less change in the color of the teeth. It has therefore nearly gone out of use as a polishing material in the dental laboratory.

Prepared chalk is as effective an agent in polishing vulcanite and celluloid work as buckhorn is with the precious metals. It is also applied mixed sparingly, at first, with water, on a No. 3 soft bristle brush-wheel until a high polish begins to appear, when it is dropped in a quite dry state upon the plate while in contact with the rapidly revolving brush-wheel.

There is always some danger of heating vulcanite plates if held with force against a rapidly revolving brush-wheel: the frequent unaccountable warping of vulcanite dentures may possibly be due to this cause; such an accident, however, need not occur if ordinary care is observed in allowing merely the ends of the bristles to come lightly in contact with the plate.

Rouge is a valuable polishing powder for gold and silver, and is much used by jewellers. It is moistened with alcohol and applied sparingly to a cotton buff-wheel running at high speed. Care should be taken to keep it from the joints in single-gum teeth dentures, as its removal is a matter of some difficulty. Calcined buckhorn has to a considerable extend superseded it on account of its greater cleanliness.

The use of the burnisher as a means of obtaining high lustre in metallic dentures has been almost entirely abandoned, because of its tendency to spring or warp metallic objects to which it is applied, and of the fact that it is unnecessary.

Adhesive wax—or rosin-and-wax cement, as it is sometimes called—which is used for the purpose of uniting parts of work preparatory to its investment for soldering, such, for instance, as a clasp to a plate when it is necessary to maintain the precise relation of one to the other until permanently fixed by soldering, and for temporarily fastening teeth

to plates while arranging and adjusting them to the mouth—is an indispensable adjunct to the dentist's work-bench and lathe. Adhesive wax is usually composed of rosin 3 ounces, wax 1 ounce. The proportions vary with the season, the quantity of wax being reduced to half an ounce for use in hot weather or when the "cement" is found to be too plastic and yielding for satisfactory use. Mastic and dammar are also occasionally added to the above formula for the purpose of stiffening it. To prepare the cement, melt the rosin and wax in a suitable vessel, and stir until the two are thoroughly mixed; test pieces should be drawn out into sticks and allowed to chill, when, if found to be but slightly brittle and of sufficient toughness to hold a porcelain tooth or clasp in their correct relation to the plate while being removed from the plaster model, the cement may be poured into a vessel of cold water, and when cool enough to handle, but still somewhat plastic, it is to be worked into sticks of about the size of an ordinary lead pencil. These are allowed to become quite cold, dusted with dry plaster to prevent them from adhering, and laid away in a box for future use.

Rosin-and-wax cement is greatly improved by age; it is therefore a good plan to keep on hand a considerable quantity of it. Shellac rolled into rods and sealing-wax are often of value when used to reinforce the adhesive wax when temporarily attaching teeth and clasps to plates previous to investing for soldering. If the cement shows the slightest tendency to yield, a small quantity of shellac or sealing-wax dropped upon it will so stiffen it that the denture may be removed from the model without change of relation between the plate and the clasps or teeth.

Fluxed Wax.—This preparation, suggested by Dr. Parr for attaching clamps and teeth in plate- and bridge-work, is put up in boxes and is applied with a hot spatula. It is said to set quickly and to hold the teeth and clasps firmly for trial in the mouth and during subsequent soldering. The "cement" throughout which the flux is distributed is readily burned or melted out, leaving the flux (probably finely-powdered glass of borax) as a deposit over the crevices and surfaces to be joined, ready to perform its office in soldering. Experts in crown- and bridge-work seem to prefer to use the rosin-and-wax cement in bulk, from which it is taken up and applied with a hot spatula.

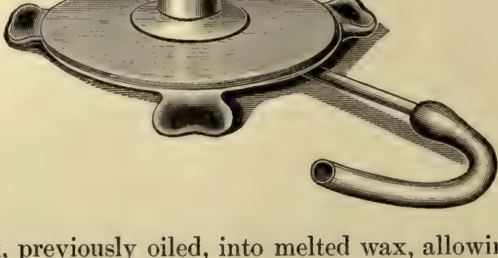
Sticks of plain wax are also very useful in "waxing up" vulcanite and celluloid cases: these may be made of the waste wax which is always found in plentiful quantity about the office and laboratory.

Sheet-wax plays an important part in the preparation of artificial dentures on bases of fusible alloys, vulcanite, and celluloid, and for additions and modifications of the plaster model preparatory to moulding for the zinc die. The ordinary base-plate supplied by the dental dépôts is generally too thick for the temporary plate of either of the cast or plastic bases. It may be safely said that much of the uncertainty of dental-laboratory manipulations with these materials is due to a want of care in the preliminary arrangement of the wax. For some unaccountable reason, the majority of mechanical dentists seem to think it necessary to make the wax plate two or three times as thick as the denture should be when finished, and after the vulcanizing to reduce it to the proper thickness with steel burs sold for the purpose, and which, on account of the danger when they are used of cutting through the plate, should have no

place in the dental laboratory. The preliminary waxing of dentures of this class should be done with such care and precision that the waxed piece will represent not only the exact thickness of the plate when finished, but all the irregularities of surface which are found on the plaster model. The rugæ and other prominences of the mouth assist in enunciation and mastication, and should be represented in the plate. It is probable that when so arranged artificial dentures feel less like foreign objects when worn in the mouth. In order not to obliterate these natural irregularites of surface the waxing should be done with two or three layers of wax, not much thicker than is used in making artificial flowers, laid on separately and pressed with the thumb, after being slightly softened in the flame of a spirit lamp or Bunsen burner, until in complete contact with the palatal portion of the model. Any desired thickness can be obtained by additional sheets of wax, but the main point to be gained by this method of waxing is uniformity of thickness; and if the waxing is artistically done, little or no scraping or finishing will be needed after vulcanizing except at the edges. Indeed, the most skilful workers in the plastic bases have demonstrated that the best results in vulcanite and celluloid work is obtained by precision in waxing and the use of tin to prevent contact with the plaster of the investment, and to afford a polished surface which shall need but little interference by the scraper. Sheet wax should not be over the $\frac{1}{32}$d of an inch in thickness: it may be prepared by dipping a square piece of plate glass or hard

FIG. 100.

FIG. 101.



wood $\frac{1}{2}$ an inch thick, previously oiled, into melted wax, allowing it to cool upon the slab, and repeating the dipping until the desired thickness is attained, after which it is stripped off, trimmed to the dimensions of 3 inches square, laid in a box, with tissue-paper between the sheets; and it is then ready for use. In the manipulation of wax a spatula of the

size and form shown in Fig. 100 is indispensable, as is also a lamp or gas-burner for the purpose of softening the wax and heating the spatula. Fig. 101 shows a small Bunsen burner which has been found to answer the purpose in every respect.

Bench Tools, etc.—The special application of tools will be found in the respective chapters devoted to the particular kinds of work in which each is used. Our remarks here will therefore be confined to their selection, care, and proper use. There are two infallible indications of the amount of training and skill possessed by a mechanical dentist: (1) The condition of his tools; (2) the state of the model after he has made a denture upon it. Skilful and accurate workmen will do so little damage to plaster casts while constructing plates or clasps that little or no evidence of their having been used will be apparent after the work is finished, showing that the tools have been well selected, kept in good working order, and correctly applied.

The addition of all the instruments and appliances used in crown- and bridge-work would very greatly augment the list of laboratory tools, but, as they will be described in the chapter on that subject, it is thought best not to include them in the ordinary equipment of the dental laboratory, which should consist of—

Plate shears, straight and curved.

Pliers (flat-nose), in at least three sizes—one pair large and strong enough to be used in drawing wire.

Pliers (round-nose), two sizes.

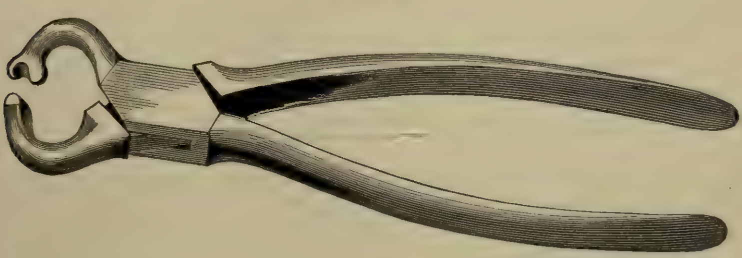
Pliers, one pair with one beak rounded and the other flat—very useful in fitting clasps.

Side-cutting nippers for removing that portion of the platinum pins which projects beyond the backing.

Punching forceps, for punching holes in gold backing for the platinum pins.

Clasp-bending forceps. There are two kinds of these instruments made. In one the jaws are at a right angle with its long axis, as shown

Fig. 102.



in Fig. 102. In dental catalogues this instrument is called a plate-bender, although it is probably never used for that purpose, but when employed to give a concave form to a piece of clasp gold, so that it may conform to the convex shape of a molar tooth, it will be found to admirably serve the purpose. The so-called clasp-benders of the dental dépôts are arranged with the jaws parallel with the long axis

of the instrument, shown in Fig. 103, and are not nearly as effective as the one shown in Fig. 102.

Fig. 103.

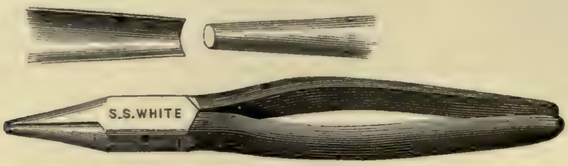


Plate-nippers are employed for removing redundant portions of a plate, which they do more rapidly than could be accomplished with files.

Plate-burnishers, straight and curved.

Horn mallet.

Riveting hammer.

Draw-plate for reducing the size of wire.

Screw-plate and taps, useful in the construction of regulating fixtures.

Plate-gauge, standard American.

Solder tweezers.

Kingsley's vulcanite scrapers, Nos. 1 and 2.

Jeweller's saw-frame and saws.

Vulcanite flasks (see chapter on Vulcanite Work).

Small steel cold chisels for cutting out chamber.

Small hammer, weighing about 2 ounces, for use with cold chisels.

Round-edged brass chaser for use in forming vacuum chambers and for carrying the plate into deep places.

Hand vice.

A small variety of sizes of gravers, chisel, and gouge forms. Those made for wood-engravers are well tempered and answer admirably for dental laboratory uses. The graver will reach places during the finishing of dentures which would be inaccessible to the corundum wheel. They are also useful in correcting slight imperfections in zinc dies.

Files, half round, 5 or 6 inches long, moderately fine cut; round files, small variety, ranging from 6 to 12 inches in length, coarse and fine; flat files with safe edge, moderately coarse and fine. Files should be kept in a suitable rack, and not in a drawer with pliers, shears, etc., as contact with these and with each other will be sure to damage them.

Triangular steel scraper for removing file-marks on edges of plate and backings.

Gas-fitter's pliers for occasional use in tightening the bolts of vulcanite flasks and other rough work which would damage the ordinary bench pliers.

Vulcanizer (see Vulcanite Work).

Vulcanite files (see Vulcanite Work).

Brass articulators (see chapter on Articulations).

Chisels for trimming around the teeth in vulcanite work.

Arkansas stone (to be used with oil), 6 inches long by 2 inches wide.

Small anvil set in lead.

Scissors, straight and curved, for cutting patterns for plates, etc.

Several points, made from broken excavators or worn-out pluggers,

used for marking upon gold or silver plates, picking wax or cement from invested cases, and numerous other purposes.

Blue pencil for marking plan of plate and clasps upon plaster models.

The use of bench tools should be strictly confined to the purpose for which they were designed. They should be carefully kept from contact with plaster of Paris, the fumes of acids, and particularly from chlorine as evolved from nitro-hydrochloric acid in the quartation process of refining gold, which readily acts upon the surface of steel and iron.

CHAPTER II.

METALS AND ALLOYS USED IN PROSTHETIC DENTISTRY.

By Charles J. Essig, M. D., D. D. S.

Metals and Alloys used in Prosthetic Dentistry.

The elements known at present number sixty-seven, divided into the metallic and non-metallic; of the former there are fifty-two, as follows:

Names.	Symbols.	Atomic weight.
Aluminum	Al	27.4
Antimony	Sb (Stibium)	120.
Arsenic	As	75.
Barium	Ba	136.8
Bismuth	Bi	207.
Cadmium	Cd	111.8
Cæsium	Cs	132.6
Calcium	Ca	40.
Cerium	Ce	140.4
Chromium	Cr	52.
Cobalt	Co	58.9
Copper	Cu (Cuprum)	63.2
Davyum	Da	(?)
Didymium	D	145.4
Erbium	E	166.
Gallium	Ga	70.
Glucinum	Be (Beryllium)	9.
Gold	Au (Aurum)	196.2
Indium	In	113.4
Iridium	Ir	192.7
Iron	Fe (Ferrum)	56.
Lanthanum	La	138.5
Lead	Pb (Plumbum)	206.5
Lithium	Li	7.
Magnesium	Mg	24.
Manganese	Mn	54.
Mercury	Hg (Hydrargyrum)	199.7
Molybdenum	Mo	95.5
Nickel	Ni	58.
Niobium	Nb	94.
Osmium	Os	198.5
Palladium	Pd	105.7
Platinum	Pt	194.4
Potassium	K (Kalium)	39.
Rhodium	Rh	104.
Rubidium	Rb	85.3
Ruthenium	Ru	104.2
Silver	Ag (Argentum)	107.7
Sodium	Na (Natrium)	23.
Strontium	Sr	87.4
Tantalum	Ta	182.
Thallium	Tl	203.7

Terbium	Ter	148.5
Thorium	Th	233.4
Tin	Sn (Stannum)	117.7
Titanium	Ti	49.8
Tungsten	W (Wolframium)	183.6
Uranium	U	239.8
Vanadium	V	51.3
Yttrium	Y	89.8
Zinc	Zn	65.
Zirconium	Zr	89.4

Of these, only fifteen are employed in their metallic condition; they are—

Antimony.	Magnesium.
Aluminum.	Mercury.
Bismuth.	Nickel.
Copper.	Platinum.
Gold.	Silver.
Iridium.	Tin.
Iron.	Zinc.
Lead.	

The metallic elements are divided by metallurgists into two classes—the noble and base metals. The first are those which are capable of being separated from combinations with oxygen by merely heating to redness; the base metals are those whose compounds with oxygen are not decomposable by heat alone.

The noble metals are ten in number, as follows:

Mercury.	Gold.	Platinum.
Palladium.	Silver.	Ruthenium.
Osmium.	Rhodium.	Davyum.
	Iridium.	

The base metals are further subdivided according to their affinity for oxygen and other chemical properties.

PROPERTIES OF THE METALS.—A metal may be defined as an elementary substance usually solid at ordinary temperatures,[1] insoluble in water, fusible by heat, and possessing a peculiar lustre, commonly spoken of as a "metallic lustre"—an expression sometimes used in describing the appearance of substances which present a similar condition of surface. To these qualities must be added those of conducting heat and electricity, which the metals possess to the greatest extent, and their power of replacing hydrogen in chemical reactions. Another characteristic of the metals is their basic properties when united with oxygen.

Arsenic and tellurium are by some chemists regarded as intermediate links between the metallic and non-metallic bodies. *Watts' Dictionary of Chemistry* classes tellurium with the "sulphur family," in consequence of its poor conducting qualities and the acid character of its oxides. Bloxam does not class arsenic with the metals, and states that, though "some authorities class it as such on account of its metallic lustre and property of conducting electricity, yet it is lacking in the quality of

[1] Mercury is an exception, being fluid at the ordinary temperature. It freezes at —40° F.

forming a base with oxygen, a property common to all true metals," and expresses the belief that "the chemical character of its compounds connect it in the closest manner with the phosphorus group.

The metals are all quite opaque, with the single exception of gold, which, however, is only transparent in leaves of a highly attenuated condition, when it transmits green light. It is believed by some that the absence of transparency in the other metals may only depend upon our inability to obtain them in a sufficiently attenuated state.

The *color* of the metals ranges from the pure white of silver to the bluish hue of lead. Between these two the major part of the others may be found. About five run from light yellow to deep red. These are—barium and strontium, pale yellow; calcium, somewhat deeper in color; gold, when pure, of a rich yellow; and copper, the only red metal. It was at one time supposed that the mineral titanium, well known to dentists as a dark-red (copper-colored) crystalline substance, used in a finely divided state as a coloring pigment in the manufacture of porcelain teeth, was a metal. Wohler and Deville, however, demonstrated that the red mineral is an oxide, and they verified their statement by producing the metal itself, which is of a steel-gray color. The color of the metals is modified by alloying.

Lustre.—This characteristic of the metals is probably the result of perfect opacity, by which the rays of light are reflected from the surface.

Odor and *taste* are possessed by a few of the metals. The greater number, however, are destitute of these qualities. Iron, copper, and zinc, when heated, evolve peculiar odors, and one means of detection of arsenic is the odor of garlic observed when that metal is exposed to an elevated temperature. Odor and taste may depend upon voltaic action. The former may be noticed in a marked degree when holding in the hand a mass of an alloy composed of gold, platinum, tin, and silver prepared for use as an amalgam alloy.

Fusibility.—All metals admit of being reduced to a liquid state by the application of heat, but the temperatures at which they melt differ widely. Thus, mercury retains its liquid form to 39° F. below zero, and is always fluid at ordinary temperatures. Potassium and sodium fuse below the boiling-point of water; tin, lead, and antimony, below redness. Gold, silver, and copper require bright redness. Iron, nickel, and cobalt fuse at white heat, while platinum, iridium, rhodium, titanium, etc. become fluid only when exposed to a powerful voltaic current or the flame of the oxyhydrogen blowpipe.

Table of Fusing-points of the Principal Metals.

		Fahrenheit.	Centigrade.
Fusible below redness:	Mercury	—39°	—39.44°
	Potassium	143.6	62.
	Sodium	203.8	95.6
	Tin	442.	227.8
	Bismuth	507.	264.
	Lead	619.	326.
	Arsenic sublimes without fusion at	356.	180.
	Zinc	773.	412.
	Antimony	842.	450.
	Cadmium	442.	227.8

		Fahrenheit.	Centigrade.
Red heat:	Silver	1873.	1023.
	Copper	1996.	1091.
	Gold	2016.	1102.
Highest forge heat:	Cobalt, rather less than cast iron.		
	Iron (cast)	2786.	1530.
	Iron (pure)	2912.	1600.
	Manganese.		
	Iron (malleable).		
	Nickel.		
Agglomerate, but do not melt in forge:	Palladium.		
	Molybdenum.		
	Uranium.		
	Tungsten.		
	Chromium.		
Fusible only in oxy-hydrogen blow-pipe:	Titanium.		
	Cerium.		
	Osmium.		
	Iridium.		
	Rhodium.		
	Platinum.		
	Columbium.		
	Tantalum.		

Specific Heat.—The capacity of different metals for absorbing heat varies with each metal. This is demonstrated by the amount of heat required to raise equal weight of different metals from the same to another given temperature. Thus, if we express by 1 the quantity of heat necessary to raise a weight of water from 0° C. to 1° C., that which must be supplied to elevate the same weight of the following metals to that temperature would be as follows:

Mercury	0.03332	Nickel	0.1086
Gold	0.03244	Cobalt	0.1070
Silver	0.0570	Iron	0.1123
Zinc	0.0955	Lead	0.0314
Cadmium	0.0567	Palladium	0.0593
Copper	0.0952	Antimony	0.0508
Tin	0.0562	Bismuth	0.0308
Platinum	0.0311		

If we should take equal bulks of these metals and expose them for the same length of time to exactly the same heat, and then place them simultaneously upon an arrangement of a number of thin sheets of wax separated from each other by means of small strips of wood of an eighth of an inch in thickness, it would be found that the number of sheets of wax perforated will vary according to the metal, the one having the highest specific heat passing through the greatest number.

Expansion by Heat.—Metals expand when heated, but this property is not uniform, some possessing it to a greater or less extent than others. Within certain limits of temperature this takes place proportionately to the amount of heat to which they are exposed. Zinc possesses a rather high degree of expansibility, and is consequently useful for the purpose of making dies for swaging metal plates for artificial dentures. By many dentists it was formerly thought that a metal to be well suited for their purpose should be entirely destitute of this property, so that after casting the die should not, in returning to its former condition in cooling, be smaller than the plaster model, the object *per se* being to have the plate fit the plaster cast perfectly; whereas the real purpose should

be to make the plate fit the mouth closely, the plaster model being only a means to that end. Plaster expands in setting. From the impression to the model two expansions are gone through before the fac simile of the mouth in plaster is obtained; hence a plate made to fit such a model perfectly must necessarily be somewhat larger than the mouth—a condition unfavorable to atmospheric adhesion. On the other hand, a plate made to fit the zinc will not be found too small for the mouth, but will, provided the impression is a good one and represents perfectly the conformation of the mouth, afford a very close-fitting plate. Even better results might be expected where the plate is somewhat smaller than the mouth, because such a condition would, in entire upper dentures, throw an undue pressure upon the alveolar ridge, while that portion of the plate covering the palatine arch would barely be in contact with the tissues; the pressure along the ridge would quickly promote absorption of the remains of the alveoli, and a uniform adaptation of the plate to the mouth would soon follow. On the contrary, if the plate be made to fit the plaster cast, and is a trifle larger than the mouth, the pressure will be thrown upon the palatine arch at the back edge of the plate, at a region not likely to change by absorption, as is the case with the alveolar ridge, and hence the margin of the plate will imbed itself in the tissues and cause much discomfort and impair the usefulness of the denture.

Much time and thought has been expended in the effort to discover some alloy which, in connection with the properties of hardness and fusibility, shall possess that of non-expansibility when heated. Professor Austen published a table of the more fusible alloys, showing the results obtained by actual experiments with reference to their relative expansibility, zinc being introduced into the table for the purpose of comparison:

	Melting-point.	Contractibility.	Hardness.	Brittleness.
1. Zinc	773° F.	.01366	.018	5
2. Lead, 2; tin, 1	440	.00633	.050	3
3. Lead, 1; tin, 2	340	.00500	.040	3
4. Lead, 2; tin, 3; antimony, 1	420	.00433	.026	7
5. Lead, 5; tin, 6; antimony, 1	320	.00566	.035	6
6. Lead, 5; tin, 6; antimony, 1; bismuth, 3	300	.00266	.030	9
7. Lead, 1; tin, 1; bismuth, 1	250	.00066	.042	7
8. Lead, 5; tin, 3; bismuth, 8	200	.00200	.045	8
9. Lead, 2; tin, 1; bismuth, 3	200	.00133	.048	7

The following table shows the relative increase in length of a bar of the metals named at 100° Centigrade whose length at 0° C is 1,000,000:

Platinum	1.00091085	Copper	1.00179673
Palladium	1.00100000	Silver	1.00200183
Antimony	1.00108300	Tin	1.00235840
Wrought iron	1.00124860	Lead	1.00285768
Steel	1.00121286	Zinc	1.00297650
Gold	1.00149824	Bismuth	1.00139200

Power of Conducting Heat.—The metals are the best conductors of heat among the solid bodies. The quality of transmitting heat is

possessed by them in variable degrees. The following table shows the relative approximate ratio of conductivity of heat of each of the metals commonly used in the mechanical arts:

	For heat.		For heat.
Silver	100.	Iron	11.9
Copper	73.6	Lead	8.5
Gold	53.2	Platinum	8.4
Tin	14.5	Bismuth	1.8

Power of Conducting Electricity.—Metals conduct electricity nearly in the ratio of their capacity of transmitting heat. Among the results of Matthiesen's investigations are the facts that debasing a metal or alloying it greatly diminishes its conducting power, that elevation of temperature has the same effect, and that between 32° and 212° F. (or 0° and 100° C.) great diminution takes places—not uniformly, however, as some lose it more in proportion than others.

The relative conducting power of metals may be observed by employing equal battery-power upon wires of the same diameter of different metals, and noting the length of the portion of each which can thus be heated. The same means may be employed to indicate the quality of electricity or the capacity of the battery itself. In this case the wire is made to demonstrate the power of the battery by the length of wire which the battery is capable of rendering incandescent.

The following table shows the relative conductivity of some of the metals, as ascertained by Matthiesen:

	For electricity, at 0° C.		For electricity, at 0° C.
Silver	100.	Tin	12.36
Copper	99.95	Lead	8.32
Gold	77.96	Platinum	18.80
Iron	16.81	Bismuth	1.24

Malleability, Ductility, and Tenacity.—These qualities differ widely in the metals. The term *malleability*, when applied to such a metal as gold, signifies that by hammering or rolling its surface may be extended in all directions, and that it is capable of being thus reduced to very thin leaves or sheets without fracture of its continuity at the edges during the process of attenuation; when applied to other metals the term should be understood as expressing this quality relatively. Gold is the most malleable of the metals, and is capable of being made into leaves of $\frac{1}{300000}$ of an inch in thickness, each grain of which will cover a surface of 54 square inches.

In the following list the metals are arranged in the order of their malleability:

1. Gold.	6. Platinum.	11. Palladium.
2. Silver.	7. Lead.	12. Potassium.
3. Tin.	8. Zinc.	13. Iodium.
4. Copper.	9. Iron.	14. Mercury (frozen).
5. Cadmium.	10. Nickel.	

Ductility signifies that property which renders a metal capable of being drawn into rods or wires, usually accomplished by passing an

elongated piece of metal through a series of gradually diminishing holes in a steel draw-plate; the granular particles of the metal are thus extended into fibres. One grain of gold has been drawn into a wire 550 feet long. To accomplish this result a compound wire is made, of gold covered with silver, the tenacity of the latter being taken advantage of to enable the gold to be carried through the successive holes of the draw-plate until the greatest possible attenuation is reached; after which it is immersed in nitric acid, which dissolves the silver, leaving a gold wire $\frac{1}{5000}$ of an inch in diameter.

In the following table the metals are arranged according to their ductility:

1. Gold.	5. Copper.	9. Nickel.
2. Silver.	6. Zinc.	10. Palladium.
3. Platinum.	7. Tin.	11. Cadmium.
4. Iron.	8. Lead.	

Tenacity is the power possessed by metals of sustaining weight or of resisting rupture when a bar or rod is exposed to tension. As the fitness of metals for certain purposes in the industrial arts depends largely upon this property, it is of the utmost importance to know the relative tenacity not only of the different metals, but of different alloys. This is usually ascertained by preparing wires of exactly equal diameters. These are suspended by one end from a fixed bar, and to the other extremity weights are gradually and carefully added until the wire breaks. The weight which causes the fracture represents, when compared with other wires similarly treated, the relative tenacity of the metals. Elevation of temperature affects the tenacity of metals, generally diminishing it. On the other hand, malleability and ductility are only developed in some of the metals by an elevation of temperature. Thus, it was found that zinc, which had previously been of no use in an unalloyed state, was rendered perfectly malleable and capable of being rolled into very thin sheets merely by heating to between 248° and 302° F. (=120° and 150° C.). If carried much beyond this point, however, say to 400° F. (=205° C.), it becomes so brittle that it may be reduced to powder in an iron mortar.

Magnesium, aluminum, and some other metals, which at ordinary temperatures are nearly destitute of ductility, have that quality greatly increased by heating, and are then readily drawn into wire. In alloys these qualities are diminished by heating.

The following table shows the order of relative capacity of the metals for sustaining weight:

1. Iron.	4. Silver.	7. Tin.
2. Copper.	5. Gold.	8. Lead.
3. Platinum.	6. Zinc.	

It must not be assumed that the three qualities of malleability, ductility, and tenacity are possessed to an equal extent by each metal. If, however, we take gold, for example, the most perfectly malleable and ductile of the metals, we shall find that in tenacity it ranks considerably

below some of the others, and the greatest care is necessary in drawing a piece of pure gold into even a moderately fine wire, and beyond a certain limit, past which platinum or copper may be carried with safety, gold would not possess sufficient tenacity to overcome the resistance to which it would be exposed in passing through the smaller holes of the draw-plate, and rupture would result.

Iron, on the other hand, which exceeds all the other metals in tenacity, is in malleability inferior to gold, silver, copper, platinum, lead, zinc, tin, and cadmium.

Crystalline metals, such as bismuth, antimony, and arsenic, do not possess these properties. They are easily broken by blows of a hammer, and the two latter may be powdered in a mortar.

Crystallization.—Under favorable circumstances probably all the metals will assume a crystalline form. Some of them, as gold, silver, etc., are found native as cubes or octahedra or in slight modifications of these forms, and metals in a crystalline form may be obtained by electrolysis. For example, silver may be obtained in the form of crystals nearly pure by introducing strips of copper into a solution of argentic nitrate. A piece of zinc introduced into a solution of plumbic nitrate will precipitate the lead in the form of feathery crystals. Gold may also be deposited in this form from solution by the introduction of a stick of phosphorus. Nearly all the metals yield crystals when deposited from their solutions by electric currents of feeble intensity.

Elasticity and *sonorousness* may be conferred upon the metals by alloying. Thus, iron does not possess these qualities until combined with the proper proportions of carbon, when by subsequent tempering the highest degree of elasticity is developed, and pieces of steel of different lengths, as arranged in the dulcimer, when struck with a small wooden hammer are capable of giving off the most musical sounds. But sonorousness is obtained to the greatest extent in alloys of copper and tin known as bell-metal. A very great amount of elasticity is obtained by the admixture of copper and zinc in the form of brass, from which a spiral spring may be made superior to that from any other alloy, and it is curious to observe how this quality may be developed by the admixture of two metals each of which, examined separately, is soft and destitute of anything like springiness. Thus, gold and platinum, both soft metals, when combined in the proportion of 1 grain of the latter to 1 dwt. of the former of 20-carat fineness, will afford a decidedly elastic alloy suitable for clasps for artificial dentures.

An elastic alloy may be formed by combining platinum with a small amount of iridium. This alloy is frequently employed in the construction of artificial dentures.

Volatility.—All metals are probably more or less volatile, although only a certain number admit of being converted with any degree of facility into a state of vapor, even at the highest temperature. Some of the conspicuously volatile metals are zinc, cadmium, mercury, arsenic, tellurium, potassium, and sodium, while a few others have the property of communicating characteristic colors to flame, and are probably volatile to a limited extent.

Metals are sometimes characterized as "fixed," as gold, copper, nickel, etc., and "volatile" (during fusion), as cadmium, zinc, etc. Arsenic

may unquestionably be regarded as belonging to the latter group, passing as it does without fusion from the solid to the gaseous state.

Gold has been known to volatilize under certain conditions, and it is doubtful whether it is at all volatile by itself; but if alloyed with copper it has been shown by Napier to be considerably volatilized, so that quantities amounting to 4½ grains could be collected during the pouring of 30 pounds weight from a crucible. According to Makins, gold has been known to volatilize when mixed with silver and lead and the metals cupelled together, he having collected considerable quantities of each metal from the chimney of an assay furnace after only a few weeks' use.

Agents which may Volatilize a Metal.—Concentration of solar rays in the focus of a lens; the voltaic current; the oxyhydrogen blowpipe flame. The three have been employed in conjunction, by which means magnesium has been volatilized, and with a powerful Bunsen battery alone carbon has been reduced by volatilization to the state of a black powder.

ALLOYS.

Most of the metals are capable of uniting with one another, forming a class of compounds termed *alloys*, in which may be observed to a greater or less extent the properties of the several constituents entering into the union.

The study of the alloys is an interesting one, as they are not only mixtures of the metals possessing certain distinct qualities, but in reality are true chemical compounds. In the appearance which often accompanies the union of the metals, and in the properties of the resulting alloys, we may frequently observe the phenomena which characterize chemical afinity, such as heat and incandescence, resulting in the formation of substances having a definite composition, distinct crystalline form, and properties differing from those of their constituents.

Alloys are generally harder and more fusible than the metals of which they are formed, and, as many metals are unfit in the pure state for use in the mechanic arts, owing to extreme softness or high fusing-point, these properties are modified to suit various requirements by the admixture of other metals.

Thus, as a base for an artificial denture pure gold would be too soft to withstand, without bending, the force to which the fixture would be exposed during mastication; but by the addition of sufficient copper and silver to reduce the gold to 750 (18 carats) the necessary rigidity may be obtained without materially affecting the other properties.

Again, it is often desirable to unite several pieces of the same metal or of different metals. This is accomplished by means of a class of alloys called *solders*, generally formed of the metal upon which they are to be employed, with the addition of some other metal which will considerably lower the fusing-point without affecting the color, as it is desirable that the place of union should not be noticeable. For example, a solder suitable for use in prosthetic dentistry should fuse at a much lower temperature than the plate upon which it is to be used. Its color should be as nearly as possible the same, and, what is even more important, it should withstand the action of the fluids of the mouth nearly as

well. These properties may be obtained by the addition of small quantities of silver, copper, or brass.

The value of many of the metals for industrial uses is very greatly enhanced by alloying. Thus, copper, which is unfit for casting and too tough for turning, may by the addition of zinc be rendered not only harder and more elastic, but the fusing-point of the resulting compound will be so much lower than that of the copper alone as to render the casting of it a matter of no great difficulty, while at the same time it will be found susceptible of being turned in the lathe with facility.

The tendency on the part of metals to unite in definite proportions may be studied in connection with platinum, iridium, gold, rhodium, ruthenium, and silver when fused with tin. If the latter metal is in excess after cooling, a metallic ingot is obtained resembling closely the tin; but by the action of strong hydrochloric acid upon this the excess of tin may be dissolved, leaving crystals of a definite alloy of the tin and the noble metal, which can be further dissolved by the same acid, but are soluble in nitro-hydrochloric acid even when the precious metal contained, whether rhodium, ruthenium, or iridium, is in the free state absolutely insoluble by that agent.

It must not, however, be assumed that the alloys employed in the industrial arts are the result of definite combination dissolved in an excess of one of the metals. Many combinations are capable of coexisting in the same alloy. This may be demonstrated in an alloy of tin, lead, and bismuth, which melts below the boiling-point of water. Heated to 25° C. and then permitted to cool, it will be observed, by the assistance of the thermometer, that the fall of temperature is twice distinctly arrested. The cause of this phenomenon has been assumed to be the production in the compound of a less fusible alloy, which in solidifying evolves heat, and thus for a time retards the gradual cooling of the mass. It may therefore be assumed that true chemical combinations may occur between two metals, notwithstanding the fact that such union may be masked by excess of one of the constituents.

According to Matthiesen, an alloy may be, first, a solidified solution of one metal in another; second, a chemical combination; third, a mechanical mixture; or, fourth, a solidified solution or mechanical mixture of two or all of the above. In simple mechanical mixtures of two metals there is often a tendency to separate. This is noticeable in some alloys of silver and copper by an absence of perfect homogeneity in the ingot. Again, some of the metals form mixtures so decidedly mechanical that on being allowed to stand after fusing they will separate, the one possessing the highest specific gravity settling to the bottom. This may be observed when lead and zinc are mixed. Matthiesen, however, found that lead retains 1.6 per cent. of the zinc. while the zinc retains 1.2 per cent. of the lead.

Density.—Theoretically, it might be supposed that the density of an alloy would be the mean of its constituents. Such, however, is not always the case, as the resulting number is sometimes equal to, or greater or less than, the theoretical mean. The density of alloys of gold and silver is less than the mean of the components, in consequence of expansion; while brass and alloys of lead and antimony vary in the opposite direction through a condensation of their constituents. But in the for-

mation of some alloys there is no alteration of volume, and the density of such will correspond to that obtained by calculation as the mean of their constituents:

Alloys having a *greater* specific gravity than the mean of their components.		Alloys having a *less* specific gravity than the mean of their components.	
Gold	and zinc.	Gold	and silver.
"	" tin.	"	" iron.
"	" bismuth.	"	" lead.
"	" antimony.	"	" copper.
"	" cobalt.	"	" iridium.
Silver	" zinc.	"	" nickel.
"	" lead.	Silver	" copper.
"	" tin.	Copper	" lead.
"	" bismuth.	Iron	" bismuth.
"	" antimony.	"	" antimony.
Copper	" zinc.	"	" lead.
"	" tin.	Tin	" lead.
"	" palladium.	"	" palladium.
"	" bismuth.	"	" antimony.
"	" antimony.	Nickel	" arsenic.
Lead	" bismuth.	Zinc	" antimony.
"	" antimony.		
Platinum	" molybdenum.		
Palladium	" bismuth.		

Color is always modified by alloying. It is generally such as might be expected to result from the mixture of the metals entering into the formation of the alloy. There are a few instances, however, where it is different. Thus, 3 parts of silver to 7 of gold yields a green alloy, and nickel added to brass produces an alloy of silvery whiteness.

Malleability, Ductility, and Tenacity.—These properties are generally much changed in metals by alloying, malleability and ductility being diminished, and in some cases entirely destroyed, even in the combination of two very ductile metals, as is the case with gold containing a small quantity of lead, ductility being completely lost. Again, gold and platinum, two exceedingly ductile metals, are rendered much harder and somewhat elastic by admixture.

The union of a brittle and a ductile metal yields a brittle alloy. According to Mr. Makins, antimony, a metal so brittle that it may be broken up in a mortar, when added to gold to the extent of $\frac{1}{1900}$ part will make the gold quite unworkable.

Tenacity is generally increased by alloying. The following results were obtained by Matthiesen by employing wires of the same gauge and noting the weights which caused their rupture before and after alloying:

	Lbs.		
Copper, unalloyed,	25 to 30;	alloyed with 12 per cent. tin,	80 to 90
Tin, "	under 7;	" " " copper,	7
Lead, "	" 7;	" " tin,	7
Gold, "	20 to 25;	" " copper,	70
Silver "	45 to 50;	" " platinum,	75 to 80
Platinum, "	45 to 50.		
Iron, "	80 to 90;	steel (iron alloyed with carbon), above	200.

Generally speaking, the hardness of metals is increased by alloying them. A familiar instance is standard gold or silver. Neither of these

when unalloyed is sufficiently hard to withstand attrition to the degree required for currency, but the addition of one-tenth of its weight of copper to either metal increases its hardness to the required point. Ninety-four parts of copper with 6 parts of tin form an alloy so brittle that it may be broken with a hammer.

Fusibility.—The fusing-point of an alloy is always lower than the least fusible metal entering into the composition of the alloy. Thus, an alloy composed of 5 parts of bismuth, 3 of lead, and 2 of tin melts at 91° C., less than the boiling-point of water, while tin alone fuses at 227.8° C. and lead at 325° C., and the addition of a small amount of cadmium to the above alloy will further reduce the fusing-point to 140° F. or 60° C. Lead combined with a small portion of silver is more fusible than the former in a state of purity, and an alloy may be formed of potassium and sodium which remains fluid at ordinary temperatures of the air.

Decomposition.—When the alloy contains a volatile metal, like zinc or mercury, heat decomposes it; but the temperature required to expel the last trace of the volatile metal must be considerably higher than that metal's normal temperature of ebullition. If the alloy is composed of a noble metal and zinc, lead, or tin, and it is desired to free it from the impurity, this may be accomplished by exposure to a high temperature and the addition, while the metal is fluid, of some substance rich in oxygen, such as potassium nitrate. By this means the base metal is converted into an oxide, and is then dissolved and held in solution by the borax which should be used as a flux in the crucible. Metals in combination with mercury may be separated by the application of heat, the mercury volatilizing at 600° F. In the case of particles of amalgam, however, the temperature to which the pieces are exposed should be at least a bright-red heat.

Influence of Constituent Metals.—Mercury, bismuth, tin, and cadmium give fusibility to alloys into which they enter; tin also gives hardness and tenacity; lead and iron give hardness; arsenic and antimony render alloys brittle. It has been observed that phosphorus and arsenic, when added to alloys of copper and tin, have the power of deoxidizing or eliminating metallic oxides, which are invariably present. The well-known phosphor-bronze owes its closeness of grain and superior tenacity to the addition of phosphorus, and it is claimed that "when arsenic or arsenical compounds are made to unite, under suitable conditions, with alloys of copper and tin, known as bronze or gun-metal, it imparts to them several remarkable and, for many purposes in the arts, desirable properties—among others and principal of which are homogeneity, hardness, elasticity, and a peculiar smoothness, rendering it a valuable anti-friction metal for journal-bearings, etc."

The arsenical compounds of alloys of copper and tin are also more fluid when molten than are other known alloys of copper and tin—a property which renders them capable of filling out sharply and without flaws the most intricate moulds.

Liquation.—The constituents of an alloy heated gradually to near its point of fusion frequently unite to form new compounds, and if the fluid portion is poured off, there remains a solid alloy less fusible than the original. Copper is separated from silver by this process. In bars

of silver alloyed with copper a curious tendency on the part of the latter to separate and aggregate at the edges as the fused mass assumes the solid form has been observed. Mr. Makins states that, as a result of careful examination of Mexican dollars and crown-pieces, he found the variation between the centre and edges to range in the former from 1 to 6, and in the latter from 1 to 4, milligrammes. He gives as the average of a number of experiments on twenty-four crown-pieces a mean variation of 2 milligrammes, and as the quality in which the greatest tendency to separate is shown that of 900 parts of silver to 100 of copper.

Temper.—Modified conditions of hardness and elasticity of a metal, it has been shown, may be obtained by mixture with other metals and by sudden variation of temperature, as in the case of the alloy of 94 parts of copper and 6 of tin, which forms a bronze so brittle that it may, when heated and slowly cooled, be pulverized with a hammer; but if, on the contrary, it is cooled rapidly by immersion in cold water, it becomes malleable. The treatment of iron mixed with carbon (steel) is just the opposite, the greatest degree of hardness being attained by suddenly cooling the heated mass.

Preparation.—When the alloy is to be formed of a noble metal and one or more of the base metals, the former should be thoroughly fused first; the latter is then added, and the whole covered with charcoal to prevent oxidation, and then thoroughly mixed by stirring or agitating.

When it is designed to lower the fusing-point of gold or silver for use as solders by the addition of brass, etc., the precious metal should first be thoroughly fused with a sufficient quantity of borax; the brass, in the convenient form of wire, should then be quickly thrust into the melted gold or silver. It will almost instantly mix with the melted mass, and the borax, if in sufficient quantity, will cover the liquid alloy, and thus protect it from oxidation by contact with the atmosphere.

The action of acids upon alloys is generally more energetic than upon a simple metal, but it varies according to the relative amounts of their constituents. Silver alloyed with a large proportion of gold is protected from the action of nitric acid. Sometimes, however, the reverse of this is seen, and metals which are totally insoluble in certain menstrua are made to dissolve in them by the addition of a metal on which they have the power of acting. Thus, platinum, although of itself insoluble in nitric acid, may be dissolved by it when sufficiently alloyed with silver.

Alloys consisting of two metals, one readily oxidizable, the other possessing less affinity for oxygen, may be readily decomposed by the combined action of heat and air. In this case the former metal will be rapidly converted into an oxide, excepting perhaps the last portions, which may in some degree be protected from further action by the oxide already formed. This increased affinity for oxygen exhibited by alloys is probably an electrical phenomenon, the study of which belongs rather to the science of chemistry than to metallurgy.

The composition of alloys used as bases for artificial dentures, and those employed as solders, will be described with the metals forming their bases.

Solders intended for use in dental mechanism should possess the quality of flowing freely, and be as high grade as the attainment of

that property will permit, so that they will resist the action of the fluids of the mouth. They should also approximate as nearly as possible to the color of the plates upon which they are used. Gold and silver solders, for all purposes of the dental laboratory, should be in the form of plate of about No. 27 of the standard gauge in thickness. This may be conveniently cut into portions or sizes corresponding to the extent of the parts to be united. Thus, upon each pin a small particle of solder should be placed, just large enough to cover it. A piece of the same size should also be placed near the top of each joint where the backings come together, while a larger piece should be placed at the point of union between backings and plate. The pieces of solder are made to adhere to their proper positions through the agency of the borax, which, as described in the preceding chapter, is used by taking a lump, rubbing it on a piece of ground glass with clean water to a creamy consistence, and then applying to the surface by means of a camel's-hair pencil.

The application and management of the heat in operations of soldering are matters requiring both care and judgment. The temperature should at first be raised very gradually, in order that pieces of solder may not be thrown off or displaced by the puffing up incident to the calcination of the borax, or, in the case of an artificial denture, that the porcelain teeth may not be fractured by a too sudden elevation of temperature. Both parts to be united should be equally heated; therefore the heat should be so applied in the case of an artificial denture as to raise the teeth and plate to an equal temperature; otherwise, should the plate become sufficiently hot while the teeth remain comparatively cool, the solder, when the flame of the blowpipe is directed upon it, will flow upon and adhere to the plate. In other words, it will manifest a preference for the hottest portion. The failure to effect an equal distribution of heat preparatory to soldering is often the cause of vexation and delay. For example, in the process of uniting a rim to a plate by soldering, the rim, being so much smaller than the plate, will be more quickly heated, in which event the solder will fuse and flow upon the rim, and the attempt to unite it to the plate will not be successful. But to avoid such a result the flame of the blowpipe should, as a preliminary step, be directed exclusively upon the plate until it has been heated to nearly the fusing-point of the solder, when the pointed blue flame may be thrown upon the latter, and union of the rim and plate can hardly fail to take place.

Combinations of Metals with Non-metallic Elements.

The metals combine with non-metallic elements to form a new class of bodies wherein none of the characteristics of the constituents are discernible. These are the chlorides, bromides, iodides, fluorides, cyanides, oxides, sulphides.

Metals also form definite compounds with nitrogen, phosphorus, silicon, boron, and carbon.

Chlorides.—All metals combine with chlorine, and some of them in different proportions, as illustrated by the stannous and stannic chlorides, the first having a formula of $SnCl_2$, while the composition of the latter is $SnCl_4$. The capacity of the metals for combination with chlorine is not uniform. The different proportions are designated by the following terms:

Monochlorides,	such as	KCl.
Dichlorides,	"	$BaCl_2$.
Trichlorides,	"	$AnCl_3$.
Tetrachlorides,	"	$SnCl_4$.

The chlorides may be prepared by acting upon the metals with nascent chlorine developed by the admixture of hydrochloric and nitric acids in the proportions of 2 volumes of hydrochloric with 1 of nitric acid.

The rationale of the action of chlorine upon metallic oxides is that it drives out the oxygen and unites with the respective metals to form chlorides. The interchange may take place at ordinary temperature, as in the case of silver oxide, but in others an elevation of temperature is required.

Many metallic chlorides are prepared by acting upon the metals with hydrochloric acid. Zinc, cadmium, iron, nickel, cobalt, and tin dissolve readily in hydrochloric acid, with liberation of hydrogen. Sometimes a chloride is obtained by substituting one metal for another. In this way stannous chloride is frequently prepared by distilling metallic tin with mercuric chloride, thus:

$$HgCl_2 + Sn = SnCl_2 + Hg.$$

Chlorides may also be prepared by dissolving a metallic oxide, hydroxide, or carbonate in hydrochloric acid.

Bromides.—Bromine unites directly with most metals, and forms compounds analogous in composition and general properties to the chlorides. Many of the saline springs contain native bromides, and silver bromide occurs as a native mineral. The affinity of bromine for the metals is inferior to that of chlorine, and the latter, with the aid of heat, drives out the bromine and converts the substances into chlorides.

Iodides are compounds possessing properties analogous to those of the chlorides and bromides, and are obtained by processes similar to those which yield the latter. With the exception of those of gold, silver, platinum, and palladium they are not decomposable by heat alone.

Fluorides are compounds formed by heating hydrofluoric acid with certain metals or by the action of that acid on metallic oxides. They may also be formed by heating electro-negative metals, such as antimony, with fluoride of lead or fluoride of mercury. The fluorides are destitute of metallic lustre, and most of them are easily fusible and bear a close resemblance to the chlorides.

Metallic oxides may be variously formed. Some metals by mere exposure to air while heated lose their metallic character, and by combination with oxygen assume a totally different appearance. There are several methods of forming oxides artificially, and some oxides are capable of being converted into others of a higher degree. Red lead, for instance, is thus formed, the metal being just heated without allowing it to fuse, when a protoxide of a yellow color is formed; but on further exposure to a temperature of 315.5° C., with free access of air, additional oxygen is taken up and the mass assumes a brilliant red color.

Oxides of metals are also formed by heating a nitrate or carbonate to redness, by which means the acid will be evolved while the oxide re-

mains. Thus, a protoxide of lead may be formed by heating the white carbonate of the metal, its color soon changing to a lemon-yellow as the acid present is driven off.

Oxides of some of the metals are formed by first acting upon the metal with nitric acid, and in that way obtaining a nitrate, which is dried and heated to dispel the acid, when the oxide will remain.

If we deflagrate some of the metals with a body containing a large proportion of oxygen, we obtain their oxides. Tin, lead, zinc, etc. are in this way removed from alloys in which they enter as prominent constituents. If 1 gramme of an alloy consisting of tin, silver, gold, and platinum be placed in a crucible and melted with borax, and then crystals of potassium nitrate added to the fluid mass, the tin will be converted into an oxide which is dissolved and held by the borax glass. If this part of the process be thoroughly performed, the remaining button will be found to contain only the noble metals, silver, gold, and platinum, which may be easily separated and weighed, thus affording a very simple method of quantitative analysis for ascertaining the proportions of amalgam alloys.

Metallic oxides in the form of hydrates are obtained by treating an aqueous solution of a metallic salt with an alkali. Thus, the hydrated sesquioxide of iron, commonly employed as an antidote in arsenical poisoning, is produced by adding ammonia to ferrous sulphate. Zinc sulphate or cupric sulphate by the addition of caustic potassa yields bulky hydrated oxides. These in turn may be converted into simple oxides by heat.

Superficial oxidation may occur gradually by mere exposure to air at ordinary temperatures, and the action will be accelerated by the presence of moisture. It frequently occurs, however, that metallic objects thus superficially oxidized are so protected by the newly-formed oxide from further access of air that oxidation can no longer go on; but should the rusted or tarnished surfaces of an iron or leaden object be removed, oxidation will again occur.

Many metallic oxides are formed during fusion of the metals. Lead and zinc are examples of this. The former by continued exposure to a sufficient degree of heat may be entirely changed into an oxide, and the latter, when carried to a temperature much above its fusing-point, burns with a brilliant light, during which the oxide is evolved in the form of white fumes, the incandescence accompanying the combination being an evidence of the intense affinity which the metal at an elevated temperature has for oxygen. The familiar experiment of converting iron into an oxide by throwing a jet of oxygen gas upon a red-hot bar of the metal is an illustration of the fact, and many metallic oxides may be formed by deflagrations.

There are, however, a few noble metals possessing so feeble an affinity for oxygen that they cannot be made to combine directly with the latter: even when the oxides of these are obtained by chemical means, the metals separate from the oxygen upon being heated to redness. Gold and platinum are illustrations of this class of metals. The latter, which is employed as a base-plate in the "continuous-gum process" and for pins in artificial teeth, is subjected to the most intense furnace heat without the slightest oxidation of surface.

Many of the metallic oxides occur in nature, a number of the metals being reduced from natural ones, which are oxides of their respective metals, such as iron, tin, manganese, chromium, etc.

Sulphides.—The metals unite with sulphur and form a class of compounds which, in a chemical and economical point of view, are almost as important as the oxides. These were formerly termed sulphurets. Many of them are found as natural ores, and are generally brittle solids possessing a high metallic lustre, the latter quality being so marked in some that they have been mistaken for gold. Sulphur combines with the metals in varying proportions, and it may be observed that combination takes place in proportions similar to the oxides, the only exceptions to this analogy being the alkalies and alkaline earths, these being but two oxides of potassium, sodium, and barium, while there are no less than five sulphides of these metals. All the metallic sulphides are solid at ordinary temperatures; most of them fuse at red heat, and some sublime unchanged. The admission of air to the heated sulphides is followed by their decomposition and conversion into sulphates, or, if they are exposed to higher and continued heat, into oxides. The sulphates are all insoluble in water, with the exception of those of iodine, potassium, strontium, barium, and calcium. The metallic sulphides may be artificially formed by the following processes: By heating the metals or their oxides with sulphur, and from the sulphates by heating them with charcoal or in a current of hydrogen through their solutions, or by adding to them a solution of an alkaline sulphide.

Reduction of Metallic Compounds.—The term "reduction," as used in metallurgy, refers to the different methods of separating a metal from its natural ores or from combination with any non-metallic element. The noble metals, for example, are separated from oxygen by merely heating to 600° F. (= 315.5° C.). Generally, however, the joint action of heat and reagents for which the non-metallic constituents of the compound have greater affinity are required.

The recent inventions of the Messrs. Cowles of Cleveland, Ohio, and of Graetzel, near Bremen in Germany, have proved to be most important advances in metallurgy. The essential feature in the improvements of these gentlemen is the application of the intense heat of a current of electricity from a dynamo machine through a conductor of great resistance in the presence of carbon. Many of the most refractory ores, which have hitherto resisted all similar attempts, may be readily decomposed in these electrical furnaces. By this means aluminum is now reduced from corundum.

The metallic compounds, whether natural or artificial, are a class of bodies formed of dissimilar elements held together by the force of chemical affinity, and which are totally unlike either of their constituents. This affinity varies much in different metals. Gold, for instance, possesses very feeble affinities, and when combined with chlorine it may be partially precipitated by mere exposure to light or the atmosphere. The facility with which it often passes from one element to another may be observed in the interesting process of manufacturing "shredded gold," in which an acid solution of the trichloride is formed and slightly heated in a glass matrass; gum arabic or sugar dissolved in water is then added, when beautiful web-like masses of pure gold are seen to form in

the liquid; but unless these are quickly removed by means of a glass spoon or dipper, they will almost instantly dissolve, and the gold again unite with the chlorine. Lead, tin, zinc, iron, and many other metals evince stronger affinities; hence they are not so readily reduced, and require, in addition to heat, the presence of other substances, such as coal, coke, charcoal, etc. In other words, it is necessary to expose them in contact with some reagent between which and the non-metallic constituents of the compound superior affinity exists, so that by union of these the metal may be released. A familiar instance of this may be found in the case of lead and zinc as used for the purpose of making dies and counter-dies in the dental laboratory. When these metals have been overheated or subjected to frequent or long-continued meltings, they become partially oxidized and covered with an earthy-looking mass consisting of semi-oxidized metal. Further exposure to heat would have the effect of converting this into an oxide of a higher degree, but if covered with finely-broken charcoal or other carbonaceous substance, such as scraps of beeswax, the usual expedient of the mechanical dentist, the oxygen will be extracted, carbonic acid will be formed and evolved, while the metal will be restored to a free state.

Chlorides.—With the exception of the chlorides of the metals of the alkalies and earths all metallic chlorides are decomposed when heated in a current of hydrogen, hydrochloric acid and the pure metal being the result. The chlorides of gold and platinum are decomposed by simple ignition.

Argentic chloride, when heated on charcoal under the flame of the blowpipe, yields pure silver and emits an odor of hydrochloric acid. Placed in water acidulated with sulphuric or hydrochloric acid, argentic chlorides may be reduced by the addition of pieces of some easily oxidized metal, such as zinc or iron, the rationale of the reaction being as follows: The zinc displaces the hydrogen of the H_2SO_4, zinc sulphate is formed, the liberated hydrogen unites with the chlorine to form hydrochloric acid, and pure silver remains.

Sulphuric acid decomposes the chlorides and converts them into oxides, the oxygen being supplied from the water present. Some chlorides may be decomposed by heating them with a metal which has more powerful basic properties. Thus, sodium when heated with aluminum or magnesium chloride will become sodic chloride, with liberation of the magnesium or aluminum. Some chlorides are reduced by heating with a mixture of sodic carbonate and charcoal; other carbonaceons compounds, such as sodic or calcic carbonate, are frequently used.

Sulphides.—Reduction of the sulphides of the noble metals, such as gold, silver, mercury, and platinum, is completely effected by heat alone. The oxygen of the atmosphere unites with the sulphur, which is evolved as sulphurous acid. In some cases, however, a portion of the oxygen combines with the metal, and an oxide instead of the free metal is obtained. The application of heat and air in some instances converts the sulphide into a sulphate, which in turn may be decomposed at high temperatures and separated into sulphurous acid and a metallic oxide. On the other hand, some of the sulphides may, when heated with access of air, be converted into permanent sulphates capable of resisting high degrees of heat.

Metallic iron, hydrogen, chlorine, etc. are frequently employed as reducing agents to combine with sulphur. If sulphides of lead be heated with iron, sulphides of iron and metallic lead result. This method is frequently practised in the assay of galena, clean iron nails being heated with the ore. The sulphides of antimony, bismuth, copper, tin, and silver are readily reduced by passing dry hydrogen over them at red heat, the result of the reaction being the free metal and sulphuretted hydrogen and sulphur. Dry chlorine will also decompose them, and combine with both the metal and the sulphur. Nitro-hydrochloric acid converts the sulphides into chlorides, and hydrochloric acid in a few instances acts similarly: its hydrogen, combining with the sulphur, is evolved as sulphuretted hydrogen. Strong nitric acid also decomposes them, and is often employed in analyses of ores. The sulphur being thus oxidized, the liberated metal combines with the acid to form a nitrate, mercuric sulphide or native cinnabar being the only ore which cannot be thus reduced.

Oxides.—The reduction of lead, zinc, or tin, the working qualities of which have been impaired by frequent meltings with exposure to air, may be effected in the laboratory by placing the metal to be treated either in a large clay crucible or in the ordinary iron melting-pot employed by dentists. The semi-oxidized metal is then covered with powdered charcoal, when the reaction described above takes place, and the original properties of the metal are restored.

There are some oxides to which the foregoing treatment is not applicable, but these may be reduced by passing a current of dry hydrogen over them when heated to redness. Makins gives the following very clear description of this method of reducing oxides:

"A large two-necked bottle is fitted up in the usual way for the evolution of hydrogen. This has its delivery-tube passed into a tube filled with fragments of calcic chloride for the purpose of absorbing the moisture which may be carried over with the gas; to the other end of this drying tube is connected the tube which is to hold the metallic oxide (generally in a bulb blown upon this). The gas-bottle should contain about a couple of quarts, so as to afford a steady supply, and the calcic-chloride tube should be long and well filled. In operating, after the gas has completely driven out the air in the apparatus heat is applied to the bulb containing the oxide, and its reduction will be brought about. The gas must be kept up in a good stream, so as to drive out the watery vapor formed by the decomposition. Here the hydrogen takes the oxygen of the oxide, and water is formed, while the metal is set free."

There are metals whose affinity for oxygen is so strong that their union with that element cannot be broken up by such means as we have described. Deoxidation of these metals must be performed through the agency of some other metal possessing greater affinity for oxygen. For example, if oxides of iron be heated with potassium, the iron will be deoxidized, while the potassium will be converted into potash (K_2O).

Some metallic oxides may be reduced by heating with sulphur, part of the latter abstracting the oxygen, with which it unites to form sulphurous acid. A portion of the sulphur, however, unites with the

metal, which is converted into a sulphur or sulphate, or a mixture of both. These must be treated according to the directions already given for the reduction of metals when combined with sulphur.

There are also a few metallic oxides which chlorine gas will reduce. Thus, platinum is liberated from combination with oxygen when exposed to a current of dry chlorine.

Probably the most powerful means of reducing metals from combination with non-metallic elements is that known as *electrolysis*. It consists in exposing a solution of a metallic salt to the decomposing influence of the galvanic current. A demonstration of this force may be made by taking a solution of nitrate of lead (plumbic nitrate) and immersing in it a piece of zinc. The latter soon becomes covered with needle-like crystals of pure lead; the zinc replaces the lead, which is set free and deposited at the point of galvanic action. Or the same phenomenon may be witnessed by immersing a piece of clean iron in a solution of copper or a piece of copper in a solution of salt of mercury, the action ceasing when all the metal in solution is reduced.

Gold.

Atomic weight, 197. Symbol, Au (Aurum).

There are evidences that processes of alloying, refining, and separating gold were practised at a very early period of the world's history. According to Pliny, the metallurgy of gold was known in his day, and it was employed in Rome for the purpose of fixing artificial teeth more three hundred years before the Christian era, and a law of the "Twelve Tables" makes exception with regard to such gold, permitting it to be buried with the dead.[1]

Occurrence, Distribution, and Properties.—Gold is of nearly universal distribution, and is found in nature chiefly in the metallic state as native gold. It occasionally occurs in combination with tellurium, lead, and silver, forming a peculiar group of minerals confined to a few localities in Europe and America, these being the only certain examples of natural combinations of the metal. The most important minerals containing gold are sylvanite or graphic tellurium $(AgAu)Te_2$, containing about 24 per cent. of gold; calavesite, $AuTe_2$, containing about 40 per cent. of gold; and nagyagite, or foliate tellurium, the composition of which is not definitely known. It contains from 5 to 9 per cent. of gold. The metallic sulphides, such as galena and iron pyrites, usually contain sensible quantities of gold, the lead ore being almost invariably gold-bearing. Native arsenic and antimony also occasionally contain gold, and a native gold amalgam has been found in California.

Gold occurs in nature very nearly, though never quite, pure, being generally associated with silver. Other metals are occasionally found combined with it, but in very small quantities, and these foreign metals are peculiar to localities. California gold, in addition to silver, which is always present, may contain iridium; Russian gold often contains platinum; and specimens of the native metal from Brazil are frequently found to contain palladium.

[1] Phillips' *Metallurgy*.

Analyses of Native Gold from Various Localities.

	Gold.	Silver.	Iron.	Copper.
United States:				
California	90.12	9.01	6.15	
Europe:				
Vigra and Clogan	90.16	9.26	trace.	trace.
Wicklow (river)	92.32	6.17	0.78	
Transylvania	60.49	38.74	...	0.77
Asia, Russian Empire:				
Beresoff	91.81	8.03	trace.	.09
Ekaterinburg	98.96	0.16	0.5	0.35
Africa:				
Ashantee	90.05	9.94		
South America:				
Brazil	94.0	5.85		
Central America	88.5	11.96		
Titiribi	76.41	23.12	...	0.87
Cariboo	84.25	14.90	...	.03
Australia:				
South Australia	87.78	6.07	6.15	
Ballarat	99.25	0.65		

Pure gold is about nineteen and a half times as heavy as water, being, with one exception (platinum), the heaviest substance in nature. It is of a rich yellow color, and is nearly as soft as lead. These properties are all sensibly modified by admixture of other metals. The tint is lowered by small quantities of silver, and heightened by copper. Owing to its exceeding softness, gold is commonly used alloyed, in order to render it capable of resisting the attrition to which coins and articles of jewelry are exposed. It is the most malleable of all the metals. One grain may be beaten into leaves which would cover a surface of 56 square inches and only $\frac{1}{300000}$ of an inch thick.

Very thin gold-leaf appears yellow by reflected and green by transmitted light. Highly attenuated films of gold, when heated, transmit rays of light of a ruby-red color. Gold is exceedingly ductile, but does not possess a very considerable degree of tenacity. A grain of gold, however, if covered by a more tenacious metal, such as silver, may be drawn into a wire five hundred feet in length. It also possesses the remarkable property of welding cold, and the metal in the state in which it is obtained by precipitation by oxalic acid may be formed into disks by compression between dies.

The specific gravity of gold varies according to condition. In the finely-divided state in which it is obtained by precipitation by oxalic acid it is 19.36. The specific gravity of cast gold is somewhat less, but when compressed between dies or by the rolling-mill it may be raised from 19.37 to 19.41. Annealing, however, will restore its previous density to nearly that of the cast metal. The atomic weight of gold is 197, and its fusing-point is 1102° C. The electric conductivity of gold is given by Matthiesen as 73.96 at 15.1° C., pure silver being 100. The conducting power, however, depends much upon the degree of purity, as the smallest addition of another metal will very considerably lower its conductivity.

The conductivity of gold for heat is stated as 53.2, as compared with pure silver, 100. Its specific heat is 0.0324.

Volatility.—The absence of uniformity in results of experiments with

regard to this property given by different investigators would seem to leave the matter still in doubt. It is quite probable that when a small portion of gold is mixed with a large quantity of zinc and heated in the air, the whole of the gold will be dissipated with the fumes of oxide of zinc. Mr. Makins has demonstrated that gold, silver, and lead when cupelled together volatilize. Gold may also be volatilized when in the form of leaf or highly-attenuated wire by passing a powerful charge of electricity through it.

Forms of Native Gold.—The native metal is sometimes found in the form of cubic crystals, in octahedra, and in irregular and more complex shapes called nuggets and dust. Crystals of gold may also be obtained artificially from an amalgam of gold 1 part, mercury 20 parts. The mixture is maintained at a temperature of 80° C. for eight days. The mercury is then removed by strong nitric acid, leaving crystals of gold, which require to be heated to redness to develop brilliancy of surface.

Gold is found in quartz veins or reefs traversing slaty or crystalline rocks, alone or associated with iron, copper, magnetic and arsenical pyrites, galena, specular iron ore, and silver ores, and more rarely with sulphide of molybdenum, tungstate of calcium, bismuth, and tellurium minerals. It is also found among the detritus of disintegrated rock[1], associated with the metals of the platinum group. In the superficial alluvial or "placer" deposits it has been remarked that the minerals with which it is found intermixed are of great density and hardness, and are the most durable constituents of disintegrated rock.

The yield of gold in easily-worked alluvial deposits is often exceedingly small. It is stated that in the Siberian gold-washings the proportion of gold ranges from 12 grains to 1 pennyweight to the ton of sand, while in the lodes which require more labor to work the proportion is but 8 pennyweights per ton, and in the "placer" washings of California it is but 12 grains to the ton of gravel. In Australia the alluvial washings of Victoria yielded 25 grains to the ton. Vein-mining, being more difficult and costly, necessitates a larger yield of the precious metal, and 5 pennyweights, or about five dollars' worth of the gold, is in most gold-bearing localities regarded as a paying quantity.

The method of obtaining gold from alluvial deposits is exceedingly simple, and consists in washing away the lighter portions, leaving the heavy metallic particles. In the early days of gold-mining in California this was accomplished by means of a pan of sheet iron, 13 or 14 inches in diameter, held in the hand and its contents exposed to a stream of water; and on the large scale consists of washing the alluvial deposits into sluices or troughs by means of continuous streams of water, mercury or amalgamated copper plates being sometimes employed to collect the finer particles of gold.

In vein-mining the separation of the gold from the rock with which it is mechanically mixed consists in reducing the latter to a fine powder in grinding- or stamping-mills, and the gold is recovered by amalgamation or by washing the pulverulent mass through troughs lined with coarse woollen cloths, by which means the lighter deposits are carried away with the current, while the heavier metallic particles become entangled

[1] In the form of small lumps called "dust."

in the fibres of the blanket, until the surface of the latter is completely covered, when it is removed and its contents are washed off in a suitable vessel and reserved for amalgamation.

In the treatment of gold by amalgamation the process is frequently retarded by a difficulty known as the "sickening" or "flouring" of the mercury. The latter, losing its bright metallic surface, is no longer capable of coalescing with other metals. The discovery was made by Wurtz in 1864 that by the addition of a small quantity of sodium to the mercury the operation is greatly facilitated, the addition of the sodium preventing both the conditions above referred to, which are produced by certain associated minerals. Some metallurgists recommend the addition of 20 per cent. of zinc and 10 per cent. of tin. It has been estimated that mercury will dissolve from 0.05 to 0.08 per cent. of native gold of standard 650 to 850 without loss of fluidity. The solubility of the gold increases with its fineness. When the point of saturation has been reached lumps of the solid amalgam are introduced into an iron vessel lined with a mixture of fire-clay and wood-ashes, and provided with an iron tube by which the fumes of mercury are passed through water and condensed, the distillation being effected at a temperature below redness. The gold left in the retort is then melted in a suitable crucible.

Gold is sometimes reduced from the mineral by exposing the ore, which has been previously roasted, to a current of chlorine gas. By this means the gold is converted into a soluble chloride, which is removed by washing with water. The precious metal is then recovered in the metallic form by precipitation with ferrous sulphate. This process is, when carefully performed, a very accurate one, and yields 97 per cent. of the gold present in the ore.

Refining Gold.—Methods of refining gold were known and practised in very ancient times, and many of them, though empirically employed, did not materially differ in principle from those in use at the present day. Thus in Strabo's time the gold was placed on the fire with three times its weight of salt and a quantity of argillaceous rock, which in the presence of moisture effected the decomposition of the salt. Hydrochloric acid is thus formed, which, at the high temperature employed, furnishes chlorine to the silver associated with the gold, which is converted into a chloride. A similar process is still practised in South America.

Among other methods for the separation of gold from silver or other contaminating metals which have been in use from a remote period may be mentioned prolonged oxidation by exposure to air and melting with sulphur, sulphide of antimony, and corrosive sublimate.

The "quartation" process of refining—so called from the fact that an alloy is formed which contains 3 parts of silver and 1 of gold—consists in first forming an alloy of the gold with silver in the proportions given. These are melted to ensure homogeneity, and granulated by pouring into water contained in a wooden vessel. The pieces are then collected and placed in a glass or platinum vessel and acted upon by either nitric or sulphuric acid. When the presence of lead or tin is suspected, this should be got rid of before subjecting the alloy to the acid; otherwise the platinum digester would be injured. The removal of lead is accomplished by cupelling the alloy, while tin may be effectually removed by fusing the alloy with potassium nitrate. On account of

greater economy and the closeness with which it will act upon silver containing very small quantities of gold, sulphuric acid is at the present day the agent most commonly employed, particularly where large quantities of the alloy are to be treated.

The nitric-acid plan does not, as a rule, yield gold of as high a degree of fineness as the sulphuric-acid treatment, but the oxidizing property of the nitric acid is of great advantage in refining gold contaminated with antimony and other equally injurious metals.

When nitric acid is employed, each ounce of the granulated alloy is treated with an ounce and a quarter of nitric acid of specific gravity 1.32.

The sulphuric-acid process is based upon the fact that the concentrated hot acid converts silver and copper into soluble sulphates without attacking the gold, the metallic silver being recovered from the sulphate in the form of needle-like crystals by thrusting copper plates[1] into it. The sulphate of copper resulting from the reaction is crystallized and becomes an article of commerce. The sulphuric acid should be of specific gravity 1.84, and the alloy is boiled for three or four hours in a platinum vessel with 2.5 times its weight of acid. The sulphurous-acid fumes which arise are partially condensed before being allowed to pass into the air. When the acid has ceased to act upon the metal a small quantity of sulphuric acid of specific gravity 1.53 is added, and after a second boiling the contents of the vessel are allowed to settle: the liquid is withdrawn from the gold, which rests at the bottom of the vessel, and is diluted until its density is 1.21 to 1.26. The gold is then carefully washed and melted into ingots, which generally contain from 997 to 998 parts of gold in the 1000.

In the nitric-acid process the supernatant liquid consists mainly of argentic nitrate. The silver may be recovered by precipitation with chloride of sodium, argentic chloride resulting, which in turn is exposed to a current of hydrogen, liberating metallic silver.[2]

The dry method of refining gold before alluded to consists in placing the granulated alloy and a mixture of 1 part of chloride of sodium and 2 parts of brick-dust in alternate layers in a crucible until the latter is full, when it is covered and placed in a wood fire and kept at a dull redness for twenty-four hours. By the united action of the moisture furnished by the wood and the silica of the brick-dust the sodic chloride is decomposed; its sodium combines with oxygen from the decomposition of the water, forming soda, which in turn unites with silica to form sodic silicate. The hydrogen of the water and the liberated chlorine form hydrochloric acid: these at the temperature at which the operation must be carried on furnish chlorine to the silver, converting it into argentic chloride. The latter, being fusible, is absorbed by the brick-dust, permitting the alloy to be further acted upon until nearly all the silver is converted into chloride, the gold remaining comparatively fine.

There is also another cementation process given[3] for the purpose of acting upon the surface of gold containing a large percentage of silver, by which means it is made to resemble fine gold. It consists in subjecting the alloy, previously rolled thin and covered by the cement-powder,

[1] Iron plates are sometimes used. [2] See chapter on "Silver."

[3] This process is attributed to Kerl, and is described in Makins's *Metallurgy*, p. 224.

to a temperature slightly below its melting-point. In this operation the mixture is composed of 1 part of sodic chloride, 1 part of alum, 1 part of ferrous sulphate, and 3 of brick-dust. At the high temperature necessary the sulphates are decomposed, with liberation of free sulphuric acid, while chlorine is evolved from the sodic chloride. These act upon the silver, which is subsequently found in the cement-powder in the form of argentic chloride.

Refining by chlorine gas, devised by F. B. Miller of Sydney, N. S. W., in 1867, is a valuable and accurate dry method for separating silver from gold. The process is the one now practised in the Australian mints, where it has been quite extensively employed, 1,100,000 ounces of gold having been refined by it in Sydney during one year, the percentage of loss during the operation being only 14 parts in the 100,000. It consists in converting the silver into chloride by the passage of a stream of chlorine gas through the molten alloy. By means of a clay pipe passing through the cover to the bottom of the crucible, and connected with the chlorine-generator by means of a flexible tube, the gas is passed rapidly through the melted metal, and is apparently absorbed by it. The refining is considered as complete when orange-colored fumes begin to rise. As soon as this evolution of gas is noticed the crucible should be removed from the fire to prevent the gold itself from combining with the chlorine. The chloride of silver, which is fusible, should be poured off from the surface of the molten metal, and, if it retains a small portion of the gold, this may be recovered by fusing with a little carbonate of soda, which causes the gold to separate and settle to the bottom of the crucible. This method is capable of producing gold of from 944 to 1000 fine.

The gold is next melted into bars, and the argentic chloride is reduced to metallic silver by placing it between two wrought-iron plates, and then immersing the whole in a vessel of water acidulated with sulphuric acid, when, after a few hours, the silver will all be reduced. It generally, however, contains a small percentage of gold, which may be recovered either by again dissolving the silver with nitric acid, when the gold will be found at the bottom of the vessel, or it may be separated by fusing the argentic chloride, to which is added a small quantity of potassic carbonate for the purpose of reducing a little metallic silver. The latter in subsiding through the argentic chloride reduces the gold, which has probably combined with the chlorine. While yet hot and in a fluid state the argentic chloride is poured off and reduced as before, when it will be found free of gold. The little button which subsides to the bottom of the vessel will be found to consist of gold, the reduced silver, and some argentic chloride. The latter must be again decomposed by fusing with potassic carbonate. Theoretically, 1 cubic foot of chlorine will convert $8\frac{1}{4}$ ounces of silver into argentic chloride, but in practice about twice that quantity is required. Thus far, the use of chlorine for refining upon a large scale has proved to be much more economical and expeditious than the humid process, the time required to part 300 ounces in 1 furnace being about two hours, and the average cost 4 cents per ounce.

Treatment of Brittle Gold.—The slightest admixture of such metals as arsenic, antimony, tin, lead, etc. is sufficient to seriously impair the ductility of gold, and the metal will require to be exposed while in a

state of fusion to a stream of chlorine gas, which removes the deleterious substances by converting them into volatile chlorides. The toughness of gold may also be restored by throwing a small quantity of corrosive sublimate on the surface of the molten metal, the vapor of which converts the metallic impurities into chloride. In the dental laboratory gold is liable to become contaminated with small particles of lead or zinc. These may be effectually removed by melting with a mixture of potassium nitrate and borax, when the foreign metals will be oxidized and dissolved in the slag.

The gold of this country is often found to contain iridium, the presence of which greatly impairs the metal for coinage and other purposes. The little hard grains occasionally met with in gold, upon which the file makes no impression, consist of iridium or a native alloy of osmium and iridium; they are not combined with the gold, but merely disseminated through it. The only dry method of separating iridium from gold consists in alloying the latter with three times its weight of silver, by which means the specific gravity of the metal is so much lowered that the iridium, which is very infusible and of a specific gravity of 21.1, will subside to the bottom of the crucible, when the gold and silver alloy may be poured or ladled off. As some gold will remain with the residue, more silver must be melted with it, the operation being repeated several times until all the gold is removed. What is left is then acted upon by sulphuric acid to dissolve the silver, when the iridium and some finely-divided gold will be left. These may be separated by washing.

Iridium may also be separated from gold by the wet process. The gold is melted with three times its weight of silver, and granulated to ensure admixture. The alloy is then treated with nitric acid, which dissolves the silver, leaving the gold and iridium at the bottom of the vessel. The gold may now be acted upon by nitro-hydrochloric acid. The iridium may then be collected and washed to free it from any portion of the gold. The latter may be recovered from its solution by precipitation, oxalic acid or sulphurous acid being usually employed.

Preparation of Chemically-pure Gold.—None of the methods which have been described can always be relied upon to afford absolutely pure gold. When nitric acid is employed in the quartation process gold may be obtained from 993 to 997 parts in the 1000, while sulphuric acid will yield gold up to 998 thousandths.

There are several methods by which chemically-pure gold may be obtained. Usually, ordinary refined gold, obtained by one of the methods above described, is dissolved in nitro-hydrochloric acid. The excess of acid is driven off, and alcohol and chloride of potassium are added for the purpose of precipitating platinum if any is present. The chloride of gold is then dissolved in pure distilled water until each gallon does not contain more than half an ounce of the chloride. Any silver present will be converted into argentic chloride, which will settle to the bottom of the vessel, after which the supernatant liquid should be carefully removed by means of a siphon. The gold may be precipitated by a stream of carefully-washed sulphurous anhydride or by the addition of oxalic acid. The precipitated metal is washed with dilute hydrochloric acid, distilled water, ammonia-water, and again with distilled

water, and is then ready for melting. This is done in a clay crucible with a small portion of bisulphate of potash and borax. The melted metal should be poured into a stone ingot-mould. By this method gold of which the purity was 999.96 has been prepared, the precipitant being oxalic acid ; but gold precipitated by that agent from an acid solution containing copper is always contaminated with cupric oxalate, to avoid which the solution should be heated with the addition of potash, when a soluble double oxalate of copper and potash is formed, leaving the gold in the pure state.

The aqua regia used in the preparation of chemically-pure gold should consist of 2 parts of hydrochloric and 1 part of nitric acid. The specific gravity of the former should be about 1.16, and of the latter 1.45. Each ounce of gold will require for its solution about $3\frac{1}{2}$ ounces of the mixed acids. The action of this upon the metal will in the beginning be quite energetic, but as the solution approaches saturation the application of moderate heat is required to dissolve the last portion of the gold. The greatest care must be exercised in the separation of the gold solution from the argentic chloride, which subsides to the bottom of the vessel, and also to rid the liquid of the small portion of silver held in solution by the acid. The solution is cautiously transferred to an evaporating dish by means of a siphon and heat is applied, and, as the bulk is gradually reduced by evaporation, more argentic chloride will be separated and deposited at the bottom. The supernatant liquid should again be carefully poured or siphoned off, and this should be repeated as often as the residue appears in the dish. When the solution has become viscid and of a deep-ruby color the heat is discontinued, and the auric chloride soon crystallizes in a mass of prismatic forms. It should then be dissolved and largely diluted with distilled water, acidulated by a few drops of hydrochloric acid, and, after standing for a few days to permit a further subsidence of argentic chloride, it should be filtered, when it is ready for precipitation. This may be accomplished by quite a number of different reagents, but the form of the precipitated metal depends upon the nature of the precipitant, and it may be thrown down in a spongy condition, in sheets resembling foil, as a powder, in a more or less crystalline state, and in scales. The affinity of gold for other bodies is so weak that care must be observed lest partial reduction be effected by merely adventitious conditions. The highly diluted neutral solution of the trichloride just described is quite liable to such accidents ; indeed, it may occur from exposure to air, atmospheric nitrogen probably being the active agent. The addition of pure water to such a solution may also cause slight precipitation, but the dilute solution may be protected from premature precipitation by acidulation with a small quantity of hydrochloric acid.

The best agents for the precipitation of gold are oxalic acid, sulphurous acid, and ferrous sulphate. Oxalic acid will precipitate several forms of gold, from sponge-like masses to the different crystalline or powdery forms. Its action is, however, slower than the others, and it requires to be slightly heated. The reaction is shown in the following equation :

$$2AuCl_3 + 3H_2C_2O_4 = 6HCl + 6CO_2 + 2Au.$$

The chlorine of the auric chloride unites with the hydrogen of the oxalic acid to form hydrochloric acid, the copious evolution of gas noticed

during the precipitation being the escape of the carbonic acid formed by the remaining elements of the oxalic acid. The gold is thus set free.

The so-called "shredded gold," somewhat extensively used by dentists in filling teeth in 1867–68, was produced by the addition of sugar or gum arabic to an acid solution of gold. The exact modus operandi is as follows: The pure gold is dissolved in nitro-hydrochloric acid, and, without evaporating the solution, it is diluted by the addition of about two-thirds its bulk of pure water. Clean gum arabic, dissolved in boiling water, to the amount of one-third the bulk of the gold solution is added to the latter, and the whole poured into a glass matrass or evaporating-dish and placed over a steam bath. When the proper temperature is attained gold in the form of leaves, shreds, or fibres will be observed floating in the liquid. When these become sufficiently coherent to admit of removal, they are lifted out by a vulcanized rubber spoon attached to a glass rod and placed in a filter. This operation is continued until the gum arabic or sugar, assisted by heat, has caused the precipitation of all the gold held in solution. The web-like masses are then thoroughly washed, dried, and heated to dull redness. As the elements entering into the composition of sugar and gum arabic are identical with those of oxalic acid, the reaction is probably the same as that which occurs when the latter is employed as the precipitant. With care in the application of the proper amount of heat the action of precipitants of this class is capable of regulation, thus affording uniform results.

When the precipitated gold is intended for plate or bars, it should be well washed, and fused in a perfectly new crucible.

Sulphurous acid precipitates gold generally in the form of a scaly metallic powder; hence it does not afford masses sufficiently coherent or sponge-like for use as a filling material for the dentist. The reaction which takes place is thus explained:

$$2AuCl_3 + H_2O + 3H_2SO_3 = 6HCl + 3H_2SO_4 + 2Au.$$

The water present is decomposed, its hydrogen uniting with the chlorine of the auric chloride to form hydrochloric acid. The oxygen of the water, attracted to the sulphuric acid, converts it into sulphuric acid, and the gold is thus liberated.

Ferrous sulphate precipitates gold in the form of a light-brown powder. Of the sulphate crystals about four times the weight of the gold is dissolved in water. This is added to the auric solution. After the finely-divided gold has entirely subsided it should be boiled several times in dilute hydrochloric acid, in order to free it from all traces of the iron with which it is liable to be contaminated. The interchange, which in this reaction results in the liberation of the gold, is expressed by the following equation:

$$2AuCl_3 + 6FeSO_4 = Fe_2Cl_6 + 2(Fe_23SO_4) + 2Au.$$

The ferrous salt parts with a portion of the iron to the chlorine of the gold salt, thus forming ferric chloride and ferric sulphate, while the gold is liberated.

As stated before, the reduction of the metal from the trichloride may be effected (in, however, a less satisfactory manner) by many different reagents, some of which are purely elementary. Thus, sulphur, selenium,

carbon (charcoal), and phosphorus, each, when introduced into a heated solution, becomes coated with a film of metallic gold. Reduction may also be accomplished by some of the gaseous bodies containing hydrogen. Thus, gold may be precipitated by arseniuretted and antimoniuretted hydrogen. Many of the base metals, such as bismuth, zinc, etc., also reduce gold from solution in the form of a brown powder. It is also reduced on a platinum pole by the electrical current. In this way the beautiful form of gold made by A. J. Watts of New York is produced. In a solution of auric chloride plates of pure gold are suspended. These are connected with a battery, so that as the solution loses its gold by deposition of the metal it is resupplied from the suspended plates. By this means large masses of perfectly pure crystal gold may be obtained.

Gold may also be precipitated by some of the metallic salts, of which nitrate of mercury and chloride of antimony may be named as examples. Quite a number of organic substances will also precipitate it, a prominent example of which is gallic acid. The tartrate, citrate, and acetate of potassium will also reduce it. Some of the members of this class, however, require the addition of heat, and to obtain prompt action with these agents the solution should be quite neutral.

Alloys of Gold.—The most important alloys are those with silver and copper. The coinage of the present day, from which the dentist usually obtains his plate, is mainly an alloy of gold and copper in the proportion of 900 parts of gold in 1000.

Alloys of gold for bases for artificial dentures should be of such fineness as will enable them to resist the chemical action of the fluids of the mouth, while at the same time they should possess the requisite hardness, strength, and elasticity. These properties are usually conferred by the addition of copper and silver or either of these metals singly, or by copper, silver, and platinum. The quality of gold which is to be introduced into the mouth should, as a rule, be of a standard of fineness not less than 18 carats. Care, however, should be observed in remelting the scraps and filings of the drawer that the grade of the gold be not lowered by the admixture of gold plates, backings, etc. containing portions of solder. Indeed, much the safer rule is to remelt only new scraps on which no solder has been used. The scraps and filings of doubtful quality may be sent to the mint for coinage, the charge for which, on the hundred dollars (the minimum amount received by the United States Mint) is less than 1 per cent.

Gold exceeding 19 carats in fineness will generally be found too soft and yielding for use in the mouth. The amount of force which the plate must sustain in mastication is much greater than might be supposed; hence, if the degree of purity of the alloy be too high, the requisite amount of rigidity and strength will be wanting, and the plate will soon bend to such an extent that it will no longer fit the mouth. This difficulty may, however, be avoided in the higher grades of gold plate intended for dental purposes by a slight admixture of platinum, by which much greater tenacity is obtained; otherwise, the plate will require strengthening by doubling at such points as are most liable to bend. Plates for partial cases necessarily require a great deal of strengthening. This adds considerably to the expenditure of time and

labor in the construction of the plate. It increases its weight, and does not always render the plate sufficiently rigid to withstand the force of mastication.

Gold plate suitable for dental purposes may be prepared according to the following formulæ:

Gold Plate 18 Carats Fine.

No. 1.		No. 2.	
Pure Gold	18 dwt.	Gold Coin	20 dwt.
Pure Copper	4 "	Pure Copper	2 "
Pure Silver	2 "	Pure Silver	2 "

Gold Plate 19 Carats Fine.

No. 3.		No. 4.	
Pure Gold	19 dwt.	Gold Coin	20 dwt.
Pure Copper	3 "	Pure Copper	25 gr.
Pure Silver	2 "	Pure Silver	40 + "

Gold Plate 20 Carats Fine.

No. 5.		No. 6.	
Pure Gold	20 dwt.	Gold Coin	20 dwt.
Pure Copper	2 "	Pure Copper	18 gr.
Pure Silver	2 "	Pure Silver	20 + "

Gold Plate 21 Carats Fine.

No. 7.		No. 8.	
Pure Gold	21 dwt.	Gold Coin	20 dwt.
Pure Copper	2 "	Pure Silver	13 + gr.
Pure Silver	1 "		

No. 9.	
Gold Coin	20 dwt.
Pure Copper	6 gr.
Pure Platinum	$7\frac{5}{7}$ "

Gold Plate 22 Carats Fine.

No. 10.	
Pure Gold	22 dwt.
Fine Copper	1 "
Pure Silver	18 gr.
Pure Platinum	6 "

Gold Plate 18 Carats Fine.

No. 11.	
United States Gold Coin ($60)	$64\frac{1}{2}$ dwt.
Pure Silver	13 "

On account of its greater strength and power of resisting the chemical action of the fluids of the mouth many dentists prefer to use gold plate 20 or 21 carats fine, in which the reducing constituents are copper and platinum, the following formula being an example:

Gold Coin	20 dwt.
Pure Platinum	10 gr.

The union of platinum with gold yields an alloy possessing great strength and considerable elasticity. Such an admixture, however, has its disadvantages. Owing to its increased strength and stiffness a much thinner and lighter plate may be employed without the additional labor and cost of doubling the plate at what in partial cases composed of ordinary 18-, 19,- or 20-carat gold would be weak points. It may also be justly claimed for gold alloyed with platinum that it will perfectly resist the action of the fluids of the mouth. On the other hand, the richness of color of the gold is always more or less impaired by the admixture of platinum. But perhaps the greatest objection to be urged against the employment of platinous-gold is the increased difficulty of swaging a plate composed of it so that it shall perfectly conform to all the depressions and irregularities of the model. Having invariably found, when the alloy contained any considerable percentage of platinum, that the ordinary method of swaging between zinc and lead was not effective, the author has for more than twenty years employed zinc for counter-dies as well as for dies: this entirely overcomes any difficulty in swaging.[1]

Gold for use in the formation of clasps should always contain sufficient platinum to render it much more elastic than the alloys usually employed in the plate or base, so that on the application of force upon the denture in the act of mastication the clasp, though it may yield slightly, will always spring together again and accurately embrace the tooth which it surrounds. In the perfect adjustment of clasps to remaining teeth the following points are of importance: First, the model must be as accurate as a plaster impression will afford; second, the clasp should be thrown around the thickest or most prominent part of the tooth; third, the clasp should be so arranged as to fit accurately the convexity of the tooth. To successfully accomplish this the gold, of about No. 26 of the standard gauge, should be cut by pattern, and before any attempt is made to fit it to the tooth it should be bent with the clasp-benders to correspond with the rounded surfaces of the natural tooth. Lastly, the contact of the clasps with the tooth should be uniform. The ends of the clasp should be free, and it should be attached to the plate at one point, so that but little of its circumference shall be included in the union; otherwise if a large proportion of the clasp be soldered fast to the plate, much of the quality of elasticity will be lost.

The following formulæ will afford alloys of 20-carat fineness suitable for clasps, backings, hard wire for crown-posts, spring wire, and wherever elasticity and additional strength are required:

Formula No. 1.

Pure Gold	20 dwt.
Pure Copper	2 "
Pure Silver	1 "
Pure Platinum	1 "

Formula No. 2.

Coin Gold	20 dwt.
Pure Copper	8 gr.
Pure Silver	10 "
Pure Platinum	20 "

[1] See chapter on "Zinc."

Alloys of Gold employed in Dentistry as Solders.—These are a class of alloys formed of the metal to be united, the fusing-point of which is reduced by the addition of silver, copper, and brass:

No. 1, 14 Carats Fine.

Pure Silver	2½ dwt.
Pure Copper	20 gr.
Pure Zinc	35 "
18-carat Gold Plate (Formula No. 11)	20 dwt.

No. 2, 15 Carats Fine.

Gold Coin	6 dwt.
Pure Silver	30 gr.
Pure Copper	20 "
Brass	10 "

No. 3, 16 Carats Fine.

Pure Gold	11 dwt. 12 gr.
Pure Silver	3 "
Pure Copper	1 " 12 "
Pure Zinc	12 "

No. 4, 18 Carats Fine.

Gold Coin	30 parts.
Pure Silver	4 "
Pure Copper	1 part.
Brass	1 "

No. 5, 20 Carats Fine, for Crown- and Bridge-work.

American Gold Coin (21.6 carats fine), $10 piece	258 gr.
Spelter Solder	20.64 "

No. 6, 20 Carats Fine, same Use as No. 5.

Pure Gold	5 dwt.
Pure Copper	6 gr.
Pure Silver	12 "
Spelter Solder	6 "

No. 7, 20 Carats Fine, for Crown- and Bridge-work.

Zinc	1½ gr.
Pure Gold	20 "
Silver Solder	3 "

No. 8, Dr. C. M. Richmond's Solder for Bridge-work.

Gold Coin	5 dwt.
Fine Brass Wire	1 "

No. 9, Dr. Low's Formula for Solder in Crown- and Bridge-work, 19 Carats Fine.

Coin Gold	1 dwt.
Copper	2 gr.
Silver	4 "

Dr. W. H. Dorrance prepares an alloy of—

Pure Silver	1 dwt.
Pure Zinc	2 "
Pure Copper	3 "

With this alloy he forms the different grades of gold solders. To form a solder suitable for bridge-work, of 20 carats fine, he melts 4 grains of the alloy with 20 grains of pure gold.

Spelter solder, composed of equal parts of copper and zinc, is sometimes employed as a constituent in the preparation of gold solders for

the purpose of reducing the fusing-point. Thus some dentists use an alloy composed of—

18-carat Gold	6 dwt.
Granulated Spelter Solder	6 gr.

An alloy of this composition is exceedingly brittle, and hence difficult to roll into plate without breaking into many pieces. Its color is good, but the author has noticed that the surface of such solders, after flowing, is apt to be pitted with small holes and has not the solid and uniform appearance that is desirable. This may be due to the oxidation and escape of some of the zinc.

Methods of Reducing Gold to a Lower or Higher Standard of Fineness, and of Determining the Carat of any Given Alloy.—The gold alloys used in the laboratory are generally made from pure gold or gold coin, the standards of which are definitely fixed. A few simple rules are here given by which the operator may readily determine the quality of alloy necessary to reduce either coin or pure gold to any desired standard.

To ascertain the carat of any given alloy multiply 24 by the weight of gold in the alloyed mass, and divide the product by the weight of the mass. The quotient is the carat sought. For example, take the following:

Pure Gold	18 parts.
Copper	4 "
Silver	2 "
	24 parts.

The result may be thus expressed:

$$24 \times 18 \div 24 = 18 \text{ carats.}$$

To reduce gold to a required carat multiply the weight of gold used by 24, and divide the product by the required carat. The quotient is the weight of the mass when reduced, from which subtract the weight of gold used, and the remainder is the weight of the alloy to be added.

To raise gold from a lower to a higher carat multiply the weight of the alloyed gold used by the number representing the proportion of alloy in the given carat; divide the product by the figures representing the quantity of alloy in the required carat. The quotient is the weight of the mass when reduced to the required carat by adding fine gold. Thus, to raise 1 pennyweight of 16-carat gold to 18 carats the numbers representing the proportions of alloys are obtained by subtracting 18 and 16 from 24. The statement is—

$$6 : 8 :: 1 : 1\tfrac{1}{3};$$

from which it will be seen that to raise 1 pennyweight of 16-carat gold to 18 carats one-third of a pennyweight of pure gold must be added to it.

Again, if instead of using pure gold we desire to raise the fineness of 1 pennyweight of 16-carat gold to that of 18 by the addition of, say, 22-carat gold, the numbers representing the proportions of the alloy would be found by subtracting, in the example given, 16 and 18 from 22, the result being—

$$4 : 6 :: 1 : 1\tfrac{1}{2}.$$

Hence each pennyweight of 16-carat gold would require a half pennyweight of 22-carat gold to raise it to 18 carats.

The fineness of gold may be expressed in decimals or in parts called carats. The former is the system employed at the United States Mint and by metallurgists and chemists, while the latter is the usual method of expressing the grade of alloys of gold among dentists and jewellers. The following table will show the relation of one to the other:

	Carats.	Decimals.
Pure gold	24	1000.
English coin	22	916.6
American coin	21.6	900.
Dentists' gold	20	833.3
" "	19.2	800.
Jewellers' gold, best	18	750.
" " good	15	625.
" " low grade	12	500.
Common jewellers' solder	8	333.3

There are many different alloys used in the arts. The greenish alloy used by jewellers contains 70 per cent. of silver and 30 per cent. of gold. "Blue gold" is stated to contain 75 per cent. of iron. The Japanese employ a compound of gold and silver the standard of which varies from 350 to 500. This alloy is exposed to the action of a mixture of plum-juice, vinegar, and sulphate of copper. They also possess a number of bronzes in which tin and zinc are replaced by gold and silver. The alloy known as shiya-ku-do, extensively used for sword-ornaments, contains 70 per cent. of copper and 30 per cent. of gold.

Alloys.—*Gold and Silver.*—The density of those natural alloys the composition of which varies from $AuAg_6$ to Au_6Ag is greater than that calculated from the densities of the constituent metals. Gold and silver unite in all proportions, affording alloys of several tints, ranging from the color of silver to that of gold. By the addition of silver the hardness of gold is increased, and it is rendered more fusible, while its malleability is not materially diminished. Gold as found in nature always contains silver, and all specimens of native silver will likewise be found to contain gold.

Gold and Platinum.—Equal weights of the two metals yield an alloy of good malleability, with, however, some dulness of color. An excess of platinum renders the alloy infusible in an ordinary blast-furnace. One part of platinum to 9.5 of gold will afford an alloy of the same density as platinum.

Gold and Tin.—Alloys of tin and gold are hard and brittle, and the combination is attended with contraction. Thus, the alloy SnAu has a density 14.243, instead of 14.828, as indicated by calculation.

Gold and Mercury.—These combine at all temperatures, but the union may be greatly facilitated by heating, and a state of fine division still further assists the process. It is stated that an amalgam composed of 6 parts of mercury to 1 of gold crystallizes in four-sided prisms, and that if the mercury is then distilled off the gold is left in an arborescent state. The operation of coating the surface of brass or copper objects with gold, extensively practised some years ago and known as "fire-gilding," was based upon the amalgamation of gold and mercury. The

process is as follows: The article to be gilded is given a uniform coating of an amalgam made by heating 6 parts of mercury with 1 part of gold, with the surplus mercury removed by squeezing. The operation is greatly facilitated by first rubbing the surface with mercurous nitrate. It is thus given a superficial layer of mercury. It is now gently heated over some burning charcoal, the amalgam in the mean time being kept uniformly distributed over the surface by means of a soft brush. As the heat is continued and the mercury is gradually driven off the surface assumes a dull-yellow color. It is then ready for polishing, which is accomplished by means of a wheel-brush moistened with vinegar. Verdigris mixed with beeswax is applied for the purpose of removing any remaining mercury by means of the affinity which the latter has for the acetate of copper. This operation, sometimes called "water-gilding," is so dangerous to health, in consequence of the liability of the operator to inhale the volatilized mercury, that it has been almost entirely superseded by electro-gilding.

Gold and copper yield a class of alloys of a reddish color (between gold and copper) which are much harder than either of their constituents. The malleability of the gold is not, however, much affected by admixture of copper, provided the latter is pure. It is stated that 7 parts of gold with 1 of copper exhibit the greatest degree of hardness which it is possible to obtain by union of these two metals. In the American coinage the alloy is chiefly copper; hence the coins are red in color and very hard.

Gold and Palladium.—These metals are stated to alloy in all proportions. Chenevix states that an alloy composed of equal parts of the two metals is gray in color, less ductile than its constituents, and has the specific gravity of 11.08. An alloy of 4 parts of gold and 1 of palladium is white, hard, and ductile. According to Makins, the merest trace of palladium with gold will render the latter very brittle. Graham has shown that a wire of palladium alloyed with from 24 to 25 parts of gold does not exhibit the remarkable retraction which, in pure palladium, attends its loss of occluded hydrogen.

Gold and Zinc.—It appears that these two metals possess a strong affinity for each other, but all the alloys of zinc and gold are more or less brittle according to the quantity of zinc present. Care should therefore be observed in the dental laboratory, where so much zinc is employed, that small particles of it do not find their way into the gold filings.

There are certain other metals which, when mixed with gold in quantities as small as the $\frac{1}{1920}$ part of the mass, render it quite brittle and unworkable. These are bismuth, lead, antimony, and arsenic.

Compounds of Gold.—Two compounds of gold with oxygen have been obtained—Au_2O and Au_2O_3—but they are of no great practical importance. The chlorides of gold correspond in composition to the oxides.

Auric chloride—or trichloride, as it is more commonly called—is prepared by dissolving gold in nitro-hydrochloric acid. The excess of acid is driven off by evaporation at a temperature not greater than 280° F. (= 138° C.); otherwise a part of it at least will be converted into aurous chloride. The crystals obtained by this process are ruby-red

in color and very deliquescent. The composition of auric chloride is $AuCl_3$; atomic weight, 303.1.

Aurous chloride is obtained by heating the crystallized auric chloride in a porcelain evaporating-dish to about 347° F. (= 175° C.). If the temperature is carried much beyond this point, say to 392° (= 200° C.), the compound will be decomposed into metallic gold and chlorine gas. Aurous chloride is yellowish in color and nearly insoluble in cold water. Boiling water, however, converts it into auric chloride and metallic gold. Its composition is AuCl; atomic weight, 232.1.

Auric chloride is the most important of the compounds of gold, and is the source from which most of the preparations of gold used in the arts are obtained. There are iodides of gold resembling the chloride in many respects. Berzelius also described an aurous sulphide. These are, however, not important.

Purple of Cassius, named for the discoverer, M. Cassius, is employed by manufacturers of porcelain teeth in obtaining the gum color, and in the industrial arts for imparting a red color to glass and porcelain. It is a compound of gold, tin, and oxygen, which are believed to be grouped according to the formula

$$Au_2O.SnO_2,SnO,SnO_2 + 4H_2O.$$[1]

It may be prepared in the humid way by adding stannous chloride ($SnCl_2$) to a mixture of stannic chloride ($SnCl_4$) and trichloride of gold. Seven parts of gold are dissolved in aqua regia and mixed with 2 parts of tin, also dissolved in aqua regia. This solution is largely diluted with water, and a weak solution of 1 part of tin in hydrochloric acid is added, drop by drop, until a fine purple color is produced. The purple of Cassius in a state of fine division remains for a time suspended in the water, but finally subsides as a purple powder. The fresh precipitate dissolves in ammonia, and exposure to light decomposes the purple solution, during which process its hue changes to blue, and it finally becomes colorless, and metallic gold is precipitated, the binoxide of tin being left in solution.

Professor Wildman obtained precisely similar results by a dry method in which an alloy of gold, silver, and tin in the following proportions are melted together and granulated:

Pure Silver	240	gr.
Pure Gold	24	"
Pure Tin	17½	"

This alloy is then acted upon by nitric acid until the silver has been entirely dissolved, when the solution should be poured off and the remaining oxide carefully washed until all traces of silver are removed. When the oxide is sufficiently washed the purple of Cassius should be dried by gently heating, and is ready to be incorporated with the silicious material, as described in detail in the chapter on Moulding and Carving Porcelain Teeth.

Hyposulphite of gold and soda, the *sel d'or* of the photographers, is a double salt formed by adding a solution of 1 part of trichloride of gold to a solution of 3 parts of hyposulphite of soda. Alcohol, in which the

[1] Bloxam's *Chemistry, Organic and Inorganic.*

double salt is soluble, is then added. The formation of this compound may be explained by the equation—

$$8(NO_2S_2O_3) + 2AuCl_3 = Au_2S_2O_3,3(Na_2S_2O_3) + 6NaCl + 2(Na_2S_4O_6).$$

Fulminating Gold.—When ammonia is added to trichloride of gold, a buff-colored precipitate results, which explodes violently when gently heated. Its exact composition is not well established.

Discrimination of Gold.—Protochloride of tin is a characteristic test for gold, affording a purple-brown precipitate. The smallest portion of gold dissolved in a large quantity of water may be detected by the addition of a few drops of this reagent. Thus, a pale-brown precipitate may be obtained in a pint of water containing but one-fiftieth of a grain of gold.

Ferrous sulphate is also a delicate test for the presence of gold, and will detect the merest trace of it. By this reagent the gold is thrown down in the form of a brown powder, which, after washing, drying, and heating to redness, yields the metal in a finely divided state.

Sulphuretted hydrogen (H_2S), added to a solution of trichloride of gold, affords a brown precipitate of auric sulphide. Nitrate of mercury also precipitates from solution a brown powder, which after heating yields finely divided gold. Finely divided gold, suspended in water, imparts a violet or red color to it. Colored fluids containing minute particles of gold in a state of suspension may be obtained by the action of phosphorus dissolved in ether upon a very weak solution of gold in aqua regia. After standing for a long time the fine particles of gold are deposited, having the same tint as that which they previously exhibited when suspended in the liquid. The blue particles, being less minute, are soonest deposited, but the red particles require many months to settle down. The one-hundredth of a grain of gold is capable of imparting a deep rose-color to a cubic inch of fluid, and the different colors thus produced are taken advantage of in painting upon porcelain, a beautiful ruby-red color being the result of the pigment thus obtained.

Assays of Gold Ores, Quartz, etc.—The specimens of ores should first be heated to redness, and then thrown into cold water to facilitate powdering, which may be accomplished in an ordinary Wedgwood mortar. Several lots of 300 grains each should be weighed and examined separately, and the assays made from these averaged for the result. To the separate portions of powdered ore equal weights of litharge, half their weights of sodic carbonate, and about half of powdered charcoal, are added and thoroughly mixed with the ore. Each portion is then placed in a crucible, a little borax sprinkled over the top, and it is ready for heating in a suitable blast- or wind-furnace. The heat at first should be gradual, so that the active effervescence caused by the escape of carbonic acid from the soda salt may not force portions of the mixture from the crucible. After a short time, however, the danger from this cause having passed, the heat may be carried to bright redness or until the whole has fused. An ingot-mould with two apertures has been recommended for the reception of the fused mixture, which at this point is ready for pouring, the slag being turned into one concavity and the reduced metal into the other. The button will be found to consist of

lead and gold, the former reduced from the litharge and the latter from the auriferous ore. These are to be separated by cupellation.

If the ore contains much iron pyrites or is of the nature of "sweeps" (the name given to residues which accumulate in the dental laboratory and other places where gold is worked), it will be necessary to roast it in a shallow fire-clay dish placed in a muffle, and in the case of pyrites containing about 7 pennyweights to the ton the operation should be conducted with 1000 grains. The roasted ore is then fused with a mixture consisting of red lead, 1000 grains; sodic carbonate, 600 grains; powdered charcoal, 40 grains; and borax, 500 grains. The mixture is introduced into a clay crucible, which it should half fill, and is fused in an air-furnace. The button of reduced lead may be removed either by pouring the contents of the crucible into a mould or by breaking the crucible when cold.

Assay by Scorification.—Scorification resembles cupellation, but the oxide of lead produced in the operation, instead of sinking into a porous cup, is held in a flat saucer of fire-clay, and dissolves the earthy constituents of the ore, leaving the precious metal to pass into another portion of lead, which remains in the metallic state. About 200 grains of the roasted ore are placed in the scorifier, and intimately mixed with 500 grains of granulated lead and 50 grains of borax. The contents of the scorifier are fused in a muffle. Air is admitted to oxidize the greater portion of the lead. At the conclusion of the operation the litharge should be perfectly fluid and cover the molten lead. The slag may be freed from particles of precious metal by the addition, at the conclusion of the operation, of a small quantity of powdered anthracite, which reduces a portion of the litharge to metallic globules, which fall through the slag and unite with the lead button. The gold is then separated by cupellation, and the silver, with which it is almost always associated, by parting with nitric acid.

Assaying.—This term refers to the quantitative estimation of one constituent of an alloy or mineral, and is accomplished by cupellation when the alloying metal is copper, and "parting" when the debasing metal consists of silver. Usually both operations are necessary. From 5 to 16 grains of the gold are wrapped in sheet lead, with pure silver equal to two and a half times the quantity of gold supposed to be present. The weight of lead employed where the assay is standard gold[1] is 8 to 1, and the ratio of the weight of lead to the weight of copper assumed to be present is 100 to 1. The assay is now to be treated by cupellation, a process which is thus briefly and clearly described by Mr. W. Crookes:

"The gold alloy is fused with a quantity of lead and a little silver if silver is already present. The resulting alloy, which is called the 'lead button,' is then submitted to fusion on a very porous support made of bone-ash and called a 'cupel.' The fusion is effected in a current of air, which oxidizes the lead. The heat is sufficient to keep the oxide of lead fused. The porous cupel has the property of absorbing melted oxide of lead without taking up any of the metallic globules, exactly in the same way that blotting-paper will absorb water, while it will not touch a globule of mercury. The heat being continued, and the current

[1] 22-carat, or coin.

of air always passing over the surface of the melted lead button, and the oxide of lead or litharge being sucked up by the cupel as fast as it is formed, the metallic globule rapidly diminishes in size until at last all the lead has been got rid of. Now, if this were the only action little good would have been gained, for we should have put lead into the gold alloy and taken it out again. But another action goes on while the lead is oxidizing in the current of air. Other metals, except the silver and gold, also oxidize, and are carried by the melted litharge into the cupel. If the lead is, therefore, rightly proportioned to the standard of alloy, the resulting button will consist of only gold and silver, and these are separated by the operation of parting, which consists in boiling the alloy (after rolling it into a thin plate) in strong nitric acid, which dissolves the silver and leaves the gold as a coherent sponge."[1]

The process of cupellation is generally performed in a furnace provided with a muffle for the reception of the cupels, and arranged so as to admit of a current of air over the fused button. The lead used in cupellation should be of absolute purity; otherwise, as lead is always liable to contain silver, the latter would necessarily combine with the assay and vitiate the accuracy of the result.

Recovery of Gold from Sweepings and Other Collections.—In addition to the methods of treating sweepings and the residues which accumulate in the dental laboratory and other places where gold is worked, sweepings—which consist of impurities of almost every kind, including fragments of porcelain teeth and other infusible substances—should, as a preliminary step, be carefully gone over and all of the larger foreign particles removed with the tweezers, after which the mass should be placed in a large crucible and brought to a bright-red heat, without borax or other fluxes, for the purpose of incinerating all combustible materials present. On cooling it will be found that the bulk of the mass has greatly decreased. It is then ready for washing for the purpose of getting rid of ash resulting from the preliminary heating. What remains should be placed in a crucible with a large amount of borax, and exposed to the highest heat attainable in a coal-stove or furnace. The button of impure gold will be found at the bottom of the crucible.

Collections from the trap of the fountain spittoon will be found to consist of fragments of gold, amalgam, oxyphosphate, and gutta-percha fillings, with pieces of porcelain and natural teeth. The latter, together with the larger masses of amalgam, should be removed by the tweezers. The mass should then be roasted in the manner described in the treatment of sweepings, washed, and melted with a very large amount of borax, the success of the operation depending very much upon the amount and duration of heat and the quantity of flux used.

Another method, which has been highly recommended, consists in fusing the sweepings or collection from the spittoon with certain substances in proportions as follows: sweepings, 8 parts; sodium chloride, 4 parts; impure potassium carbonate, 4 parts; potassium supertartrate, 1 part; and potassium nitrate, ½ part. These are to be mixed thoroughly and melted in a crucible, and in order to secure complete separation of the metals from extraneous matter the crucible with its contents

[1] See "Quartation."

should remain in the fire at the highest attainable temperature for at least an hour. The resulting button of impure gold will necessarily be of uncertain quality, and will require treatment by the quartation process to reduce it to pure gold, when it may be again definitely alloyed to the finest required for use in the dental laboratory.

Silver.

Atomic weight, 108. Symbol, Ag (Argentum).

Properties of Silver.—Silver is distinguished from all other metals by its brilliant whiteness. Its specific gravity is 10.53. In hardness it is between gold and copper. It is one of the most ductile and malleable of the metals, and when calculated by weight it is not even surpassed by gold. For example, 1 grain of gold may be beaten out to the extent of 75 square inches, and the same weight of silver to 98 square inches. Taking a cubic inch of gold at 4900 grains, this gold-leaf is $\frac{1}{366950}$ part of an inch in thickness, or about twelve hundred times thinner than ordinary printing-paper.[1] But the silver, though spread over a larger surface, will be thicker, owing to the difference of specific gravity between gold and silver. The extent of the malleability of gold and silver has not yet been definitely determined, as the means employed to test it have failed before there was any appearance of the malleability of either of them being exhausted.[2]

In tenacity silver surpasses gold. It fuses at about 1873° F., and during the fusion absorbs oxygen to the extent of about twenty-two times its own volume; but at the instant of solidification it undergoes considerable expansion, while at the same time it parts with the oxygen, which makes its escape through the thin crust formed over the fluid metal, carrying with it fine globules of the metal, which may be observed adhering to the sides of the crucible. It is the best conductor of heat and electricity known. It possesses no direct attraction for oxygen; hence it is not oxidized by dry or moist air at any temperature. It is, however, oxidized by ozone, and tarnished by air containing sulphuretted hydrogen, which blackens the surface with a superficial layer of sulphide of silver, which may be removed by a solution of cyanide of potassium.

With the exception of nitric, silver is not affected by dilute acids; but hot concentrated sulphuric acid converts it into sulphate of silver, and when boiled with strong hydrochloric acid it dissolves to a slight extent in the form of chloride of silver, which is precipitated by the addition of water.

Occurrence and Distribution.—In the Middle Ages, Austria was the chief source from which silver was obtained as an associate metal with lead. At the present day the United States, Peru, and Mexico supply large quantities.

Silver is found, first, as native silver, occurring in flat masses occasionally and sometimes crystalline in form. In this country it occurs with native copper, masses frequently being met with in which the two metals are diffused, the silver showing in specks upon the copper.

[1] Gold has, for the sake of experiment, been beaten out to the extent given above, but the $\frac{1}{300000}$ of an inch, as given on page 94, is as thin as is ever required for practical purposes.

[2] W. Chandler Roberts, assayer Royal Mint.

Native silver is usually free from any considerable admixture with other metals, although it invariably contains traces of gold, antimony, etc. It is also found as chloride, iodide, and bromide.

The most common ores from which silver is derived are those resulting from combination with sulphur and sulphides. These may be divided into three kinds. First may be mentioned the common sulphide of Mexico, called "vitreous sulphide." It is a protosulphide, is very fusible, and readily yields silver when made to give up its sulphur. Another sulphide, closely resembling the first, called "brittle silver ore," is found in South America and in some parts of Europe. It is readily decomposed by heat, and during exposure to high temperatures evolves fumes of arsenic and antimony. A third sulphide, found in nearly all silver-mines in the form of ruby-colored, transparent crystals, is called "red silver ore," and is associated, to some extent, with oxides. The composition of this ore has been given as follows: Silver, 56 to 62; antimony, 16 to 23; sulphur, 11 to 14; oxygen, 8 to 10.

The chloride, or native horn-silver, is quite an abundant ore of South America (Chili). It is a true chloride, and, like precipitated chloride of silver, darkens when exposed to sunlight. Its composition is given as—silver, 75.3; chlorine, 24.7.

Methods of Separating Silver from its Ores.—As much of the silver of commerce is extracted from ores too poor to admit of its economical separation by any process of melting or fusing, even in regions where fuel is plenty, recourse to the method known as "amalgamation" is necessary. This depends simply upon the easy solubility of silver and associated metals in mercury. The ore is crushed to powder, mixed with a sufficient quantity of common salt, and roasted at a dull-red heat in a suitable furnace. By this treatment any sulphide of silver contained is converted into chloride. The mixture, which consists of much earthy matter, metallic oxides, soluble salts, silver chloride, and metallic silver, is sifted and placed in barrels arranged to revolve on axes. Scraps of iron and water are added, and the whole agitated together for the purpose of reducing the silver chloride to the metallic state. A sufficient quantity of mercury is then added, and the agitation continued until the metallic particles are dissolved, forming a fluid amalgam which is readily separated from the mud or earthy matter by subsidence and washing. It is then strained through a strong linen cloth or other suitable fabric to separate the fluid mercury from the more solid portions of amalgam. These latter are subsequently exposed to heat in a retort, by which the remaining mercury is distilled off. The silver, more or less impure from admixture with other metals contained in the ore, is thus obtained.

In order to prevent loss during the amalgamation process in consequence of a tendency on the part of the mercury to combine with sulphur, oxygen, etc., technically known as "flouring," in which condition it may be washed away together with the silver it has taken up, from 1 to 2 per cent. of sodium is added to the mercury. The great affinity of sodium for sulphur and oxygen prevents "flouring" of the mercury.

Considerable quantities of silver are obtained from argentiferous galena,[1] and, indeed, it may be stated that nearly every specimen of

[1] Silver is invariably present in this form of lead ore, but not always in paying quantities.

native lead sulphide will be found to contain traces of the nobler metal. When the proportion of the precious metal present is sufficiently large to ensure its profitable separation, the ore is reduced as usual,[1] the silver remaining with the lead, and is then treated according to a process discovered by Mr. Pattinson, by whom it was found that when lead containing a considerable amount of silver is fused and carefully stirred while it is allowed to cool slowly, crystals much less rich in silver than the mass before melting will form, and separate and subside to the bottom. These crystals of poorer lead are removed by means of perforated ladles. The silver is thus concentrated. The method of separating silver from lead, as practised on a large scale, is thus described by Mr. Makins in his *Manual of Metallurgy:*

"A series of iron pots, from nine to twelve in number, are employed. These are hemispherical, about 5 feet in diameter, and calculated to hold a charge of about nine tons of metal each. They are set in brick furnaces adjacent to one another, but with quite distinct flues, furnaces, dampers, etc. The lead, assorted according to its richness in silver, is then placed in the pots in the following order: Some lead containing 10 ounces of silver per ton having to be worked, 9 tons of it would be placed in the fifth pot and melted. After complete fusion it is skimmed with a perforated ladle, which removes the dry oxides for subsequent reduction, while it permits the fluid lead to run back into the pot. The fire is then drawn, and the metal stirred while it slowly cools until it begins to thicken. The workman at this stage of the operation employs an iron ladle of 18 inches in diameter by 5 inches deep, perforated with half-inch holes and furnished with a very long handle. This handle he raises above his head, sinking the bowl into the lead until it reaches the bottom. Then, by using the handle as a lever and depressing it as far as possible, the ladle full of crystals is brought into view, and by means of a hook and chain fastened to a crane is suspended and left to thoroughly drain, after which the crystals are turned into the fourth pot. This operation is continued until two-thirds of the lead in the fifth pot have been passed over in crystals to the fourth pot, under which a fire is made and the crystals again melted. The remaining 3 tons of molten lead in the fifth pot, which by the separation of the crystals contains silver equalling 20 ounces per ton, is now ladled into the sixth pot. The results of the preceding operations may be summed up as follows: In pot 5, 9 tons of ten-ounce lead equals 90 ounces of silver, of which 6 tons of five-ounce (30 ounces silver) works into pot 4, and 3 tons of twenty-ounce (60 ounces silver) is ladled into pot 6. The work now proceeds until all the pots are in operation. Three tons of five-ounce lead would be added to the 6 tons passed into pot 4, while 6 tons of twenty-ounce lead would be carried into pot 6. Six tons from pot 6 would work into No. 5, and 3 tons in bottoms will be put back into the same pot from No. 4, filling it again without the addition of pig-lead. The bottoms or portions which remain after the ladling become by that process so rich in silver as to often contain 600 ounces to the ton. This is finally submitted to cupellation, by which means the complete separation of the silver is effected."

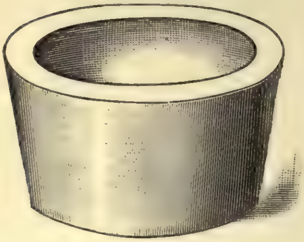
The cupel and its application may be thus briefly described: Bone-

[1] See chapter on "Lead."

ash is mixed with water, made into a cup in a suitable mould, and dried. This is called the cupel,[1] and has the property of absorbing oxides when they are combined with oxides of lead in a state of fusion. Impure silver is mixed with a certain quantity of lead, determined by the amount of impurity supposed to exist in the alloy. The mixture is melted in the cupel in a current of air until the whole of the lead is converted into oxides, which in a fused state sinks into the porous cupel, carrying along with it the impurities, the silver being left behind in a pure state. The whole operation is based on the absence of attraction for oxygen evinced by the noble metals even when exposed to high temperatures, and on the affinity possessed by the base metals for oxygen under similar conditions.

Cupellation may be accomplished either in a muffle arranged with reference to the passage of a current of air, so that oxygen may be freely supplied to the melted metal, or it may be performed under the oxidizing flame of the blowpipe. The latter operation is often employed in blowpipe analysis. A certain amount of the alloy is mixed with about four times its weight of pure lead, and then placed on the cupel and the oxidizing flame of the blowpipe directed on it. The oxidizing process soon begins, and in about thirty minutes all the lead will be converted into litharge, which is fusible and is readily absorbed into the porous substance of the cupel, carrying with it all the oxidizable metals that may be present. At this point the button, having parted with every trace of the latter, assumes an exceedingly bright appearance, technically called the "brightening of the button," thus offering a certain means of ascertaining when the process of cupellation is complete. Cupellation under the oxidizing flame of the blowpipe for quantitative discrimination requires careful management, particularly when the silver has parted with the base metals and approaches a state of purity; for it is at this stage of the operation that the well-known property of melted silver, of absorbing oxygen from the atmosphere and then parting with it as it approaches the point of solidification, may be observed. The giving off of the absorbed oxygen is what causes "sputtering," by which minute globules of the metal are thrown off and lost, thus rendering the assay inaccurate.

FIG. 104.



The cupel.

Besides the method of obtaining silver above described, the metal may be obtained by converting sulphide into chloride, the latter being easily reduced to metallic silver by the wet method. The sulphide is also sometimes converted into sulphate, when the silver may be reduced from the solution by precipitation.

Another method of separating silver from its ores consists in roasting the latter with common salt to convert the silver into chloride, which is dissolved out of the mass by means of a strong solution of chloride of sodium; the silver is then recovered in the metallic state by precipitating with copper. Hyposulphite of soda has also been employed to dissolve

[1] Cupels may be obtained at the chemists' furnishing-shops ready for use.

out the chloride of silver, the resulting solution, being precipitated by sulphide of sodium, yielding sulphide of silver, which requires roasting to drive off the sulphur and liberate the metallic silver.

Compounds of Silver.—There are three compounds of silver with oxygen: the suboxide, AgO; the oxide, Ag_2O; and the peroxide, which is thought to have the formula of Ag_2O_2. The oxide is the only one having any practical importance. Being the base contained in the salts of silver, it is obtained by adding caustic potassa or baryta-water to a solution of nitrate of silver.

Silver nitrate ($AgNO_3$) is prepared by dissolving silver in nitric acid by the aid of gentle heat, after which it is evaporated to dryness or until it crystallizes. These crystals are colorless, transparent, and soluble in an equal weight of cold and in half the quantity of boiling water. They are also soluble in alcohol. Nitrate of silver is fusible, and when poured into cylindrical moulds forms the lunar caustic employed by surgeons. At high temperatures (red heat) it is decomposed, yielding pure metallic silver.

Silver sulphate (Ag_2SO_4) is prepared by boiling metallic silver in sulphuric acid.

Silver sulphide is remarkable for being so soft and malleable that medals may be struck from it. It may be formed as a black precipitate by the action of hydrogen sulphide (H_2S) upon a solution of silver nitrate, or it may be formed by heating silver with sulphur in a covered crucible. It is the affinity existing between these two elements which renders the combination of silver and vulcanizable rubbers impracticable. Silver sulphide is not soluble in dilute sulphuric or hydrochloric acid, but is readily dissolved by nitric acid. Metallic silver also dissolves sulphide of silver when melted with it.

Silver chloride ($AgCl$) is the form into which silver is commonly converted in separating it from other metals or from its ores. It is a white, curdy precipitate, and may be obtained from a solution of the nitrate by the addition of sodium chloride or hydrochloric acid. When freshly prepared it is perfectly white, but soon darkens, and eventually becomes quite black by exposure to solar light, parting with a portion of its chlorine and becoming a subchloride (Ag_2Cl).

Silver chloride may also be formed by suspending a silver leaf in a glass vessel containing chlorine gas, and when thus prepared it is not blackened by exposure to light. Argentic chloride is fusible at 500° F. A much higher heat converts it into vapor, but does not decompose it. It is soluble in ammonia.

Discrimination.—The chlorides and hydrochloric acid precipitate white argentic chloride, and so delicate is the test that when 1 part of silver is dissolved in 200,000 times its weight of water it may be readily detected by the opalescence which is imparted to the fluid by the precipitant. This precipitate is always changed to a violet-black by exposure to light, but the presence of mercury[1] will prevent discoloration. It is insoluble in nitric acid, but is readily soluble in ammonia, and may be fused to a horny mass without decomposition.

Sulphuretted hydrogen added to a solution containing silver throws down a black precipitate of silver sulphide, which is not soluble in dilute

[1] Mercurous chloride.

acids, alkalies, or potassic cyanide. Sulphuric acid at a temperature of 212° F. will, however, dissolve it, with separation of the sulphur.

Ammonia or potassa, when employed as a precipitant, throws down a brown oxide, insoluble in the latter, but soluble in the former, and if freely exposed to air this solution will deposit fulminating silver.

The blowpipe is frequently used in the discrimination of silver compounds, which when heated on charcoal with sodic carbonate yield a bright bead of metallic silver, often accompanied by a red-colored deposit on the charcoal.

Quantitatively, the estimation of silver may be accomplished either by the usual humid process or by assaying. The first consists in precipitating the metal as chloride, which is to be separated and weighed. The precipitation is effected as follows: The silver solution is acidulated by nitric acid; hydrochloric acid or sodic chloride, slightly in excess, is then added, but, as silver chloride is to a certain extent soluble in either of these, an undue excess must be avoided. The chloride must now be carefully and repeatedly washed and filtered in a thoroughly dry filter, previously weighed. After the solution has passed through the filter the latter with its contents is dried and weighed, and the weight, minus the weight of the filter, will be the quantity of silver chloride present.

The dry method or assaying process consists in forming an alloy of the silver with lead, and is especially applicable to ores and the sweepings of the dentist's laboratory. The specimen to be treated is heated with from twelve to thirty times its weight of pure granulated lead in a bone-ash cupel, which is placed in a muffle so arranged that a current of atmospheric air may pass freely over the vessel and oxidize the lead. This oxide of lead, being quite fusible, combines with any base metal present and oxidizes it, uniting subsequently with the oxide as a fusible slag, while the gold or silver will be held by the unoxidized portion of the lead. In the treatment of specimens of alloys, such as plate or coin, a quantity of the specimen is accurately weighed and mixed with from four to five times its weight of pure granulated lead. It is then placed in the cupel and exposed to heat, as above described, until all the lead is oxidized or converted into litharge, when the remaining button assumes the brilliant appearance of surface before alluded to, which denotes that the base metals or oxidizable constituents have been oxidized and taken up by the lead oxide. This button is then to be weighed by means of a delicate assay-balance, and the loss of weight shows the proportion of alloy that was present.

Pure Silver.—Pure silver, which is reckoned as 1000 fine, may be obtained from standard or other grades of silver by dissolving them in nitric acid slightly diluted with water, the solution being much facilitated by exposure to gentle heat. If gold be associated with the alloy, it will be found at the bottom of the vessel, in which case it will be necessary to use a siphon to remove the argentic nitrate solution. The silver is now to be precipitated in the form of chloride by the addition of an excess of common salt. When all has subsided the liquid is carefully poured off and the chloride thoroughly washed to remove all traces of acid. The chloride is then placed in water acidulated with hydrochloric acid (an ounce of chloride requiring 6 to 8 ounces of water), and pieces of clean wrought iron put in it, when a copious evolution of hydrogen follows,

which, uniting with the chlorine of the argentic chloride, liberates metallic silver. The latter should not be disturbed until the last particle of it is thus reduced, when it will be found to be a spongy mass. The undissolved iron should now be carefully removed, the ferrous and ferric chloride carefully decanted, and the silver washed in hot water containing about one-tenth its bulk of hydrochloric acid. This is repeated several times, and finally the silver is again thoroughly washed with pure hot water. The silver, after drying, is then ready for melting, and if care has been observed in the process it will be found to be of a fineness of 999.7 parts in 1000, the 0.3 of impurity present being due to traces of iron. The chlorides may be acidulated with sulphuric acid, and reduced with zinc instead of iron.

Another method of precipitating silver in the metallic form consists in placing a sheet of copper in a solution of argentic nitrate. The metal is thrown down in a crystalline form. Silver thus obtained is never free from traces of copper.

Pure silver can only be obtained from samples of a lower grade by fusing the pure chloride with sodic carbonate. The reaction is shown in the equation:

$$2AgCl + Na_2CO_3 = Ag_2 + 2NaCl + O + CO_2.$$

Owing to the copious evolution of carbonic-acid gas which takes place during the decomposition, some of the silver may be thrown from the crucible, and loss may occur by the absorption by the crucible of some of the fused chloride. To avoid this the sides of the vessel should be coated with a hot saturated solution of borax. A composition of 100 parts of argentic chloride, 70.4 of calcic carbonate (chalk), and 4.2 of charcoal has been recommended as a means of obtaining pure silver. This mixture is heated to dull redness for thirty minutes, and is then raised to full redness; carbonic acid and carbonic oxide are given off; the calcic chloride is converted into calcic oxychloride, underneath which, in the bottom of the crucible, will be found the button of pure silver.

Alloys of Silver.—In consequence of its softness, silver in the pure state is liable to considerable loss by attrition. For all useful purposes, however, the requisite amount of hardness may be conferred upon it by the addition of a small proportion of copper. Thus, silver for coinage and manufacturing purposes usually contains in 1000 parts from 900 to 925 of silver and from 75 to 100 of copper. The term "standard silver" refers to the metal thus alloyed with copper, that of the United States coinage being—silver 900 parts, copper 100.

Previous to the introduction of vulcanized rubber as a base for artificial dentures standard silver was much employed in the United States for temporary dentures when cheapness was an important consideration. In England a much more durable alloy is used, in which the alloying metal is platinum, in the proportion of from 3 to 10 grains of the latter to each pennyweight of silver. The advantages possessed by this alloy over ordinary standard silver may be summed up as follows: It resists wear better, and not even a suspicion can be reasonably entertained of any ill effects occurring, either locally or to the general system, from its presence in the mouth. It permits of the employment of a higher grade

of solder, and it is a much more rigid alloy than ordinary standard or coin silver. Hence it makes a stronger artificial denture, which is less likely to have its adaptation impaired by bending. But, while silver is improved in some respects when platinnm is the sole alloying component, it must not be supposed that its affinity for sulphur is thus materially lessened, or that its tendency to blacken when brought into contact with that element or its compounds is obviated. Indeed, it may be stated that platinum added to silver in such small quantities does not wholly protect the latter from the action of its ordinary solvents. Such an alloy of silver, for instance, would not only be readily dissolved by nitric acid, but the platinum also, though unaffected ordinarily by that menstruum, would readily yield to it when combined with silver.

This alloy of silver, which is known in England as "dental alloy," often contains from 25 to 30 per cent. of platinum. To separate the latter metal from the silver the alloy is dissolved in nitric acid, which on the addition of heat will dissolve all of the silver with about 10 per cent. of the platinum. On introducing a bar of copper into this solution the silver and platinum are quickly precipitated in a metallic state. This precipitate is again placed in nitric acid, which redissolves the silver, leaving the platinum untouched, which, however, may be dissolved, with the other 15 or 20 per cent. of the platinum left at first, in aqua regia. Precipitating by an excess of ammonium chloride, evaporating to dryness, and igniting yields pure platinum. The silver may be recovered in the usual way by precipitation in the form of a chloride, which may be easily reduced to a metallic state by treating with a plate of zinc in acidulated water.

It is a somewhat common belief that the putting together of silver and platinum in the formation of an alloy of this kind, owing to the infusibility of platinum and the wide difference in the fusing-points of the two, is a matter of great difficulty. It should be borne in mind, however, that between the metals more or less affinity exists, especially at high temperatures; hence it is only necessary to introduce the platinum, rolled into thin ribbons, into the crucible containing the silver in a state of complete fusion, and the platinum will be observed to quickly fuse and mix with the other metal. It is sometimes thought advisable to add larger proportions of platinum than the quantity here given. This may be done by adding the platinum until the alloy becomes infusible; and this result will be attained as soon as sufficient platinum is added to raise the fusing-point of the alloy above the capacity of the ordinary melting apparatus.

Von Echart's alloy, employed to some extent in France as a base for artificial dentures, is composed of the following proportions: silver, 3.53; platinum, 2.40; and copper, 11.71. It is very elastic (which property it does not lose by annealing) and can be highly polished.

Silver Solders.—When the plate to be united consists of pure silver alloyed with platinum, the solder may be formed of the standard metal (coin), with the addition of from one-tenth to one-sixth its weight of zinc according to the proportion of platinum contained in the alloy. Silver solders are, however, generally composed of silver, copper, and zinc, or silver and brass, in variable proportions, of which the following are examples:

No. 1.[1]

Silver	66 parts.
Copper	30 "
Zinc	10 "

No. 2.[2]

Silver	6 dwt.
Copper	2 "
Brass	1 "

No. 3.

Silver	5½ dwt.
Brass wire	40 gr.

In putting together the constituents of silver solders the affinity for oxygen manifested by zinc, brass, and copper when exposed to high temperatures should be remembered, and in order to guard against loss the mode of procedure should be as follows: The silver, placed in a clean crucible, with a sufficient quantity of borax to cover it, should be thoroughly fused, and, without permitting it to cool in the least, the zinc, brass, or copper, as the case may be, should be quickly added. Before pouring it should be shaken or agitated to ensure admixture. When cool it may be removed from the ingot-mould and rolled into plate of, say, No. 27 of the standard gauge.

The surface of standard silver may be whitened by being heated and immersed in dilute sulphuric acid. It is in this way that frosted silver is produced. The acid, dissolving the oxide of silver from the surface, leaves a quite pure superficial film.

Silver may be deposited upon the surface of another metal by connecting the article to be silvered with the negative (zinc) pole of the galvanic battery, and then immersing it in a solution made by dissolving cyanide of silver in a solution of cyanide of potassium. The current decomposes the argentic cyanide, and the metal is deposited upon the object connected with the negative pole. During this decomposition the cyanogen liberated at the positive (copper or platinum) pole acts upon a silver plate with which this pole is connected, the quantity of silver dissolved at this pole being precisely equal to that deposited at the opposite pole: the silvering solution is always maintained at the same strength.

Platinum.

Atomic weight, 197.6. Symbol, Pt.

Platinum is found in nature in flattened grains of varying sizes, more or less alloyed with palladium, rhodium, ruthenium, davyum, and iridium.[3] It occurs in Brazil, Peru, Australia, and California. Russia, however, furnishes the largest supply of platinum, from the Ural Mountains. It was discovered in 1736 by Anton Ulloa at Choco, in South America, but in consequence of its infusibility and unworkable nature no use was made of it, and its presence in mining products was considered

[1] Richardson's *Treatise on Mechanical Dentistry*. [2] *Ibid.*

[3] A group of rare metals only found in platinum ores, and known as the "platinum metals."

a detriment. Dr. Wollaston devised the first practical process of working it, and in 1859, Deville and Debray published improved methods of fusing large quantities of platinum.

Wollaston's method, which consists of a series of chemical and mechanical processes of a rather complicated nature, may be thus described: The ore is first heated with nitric acid to dissolve any copper, lead, iron, or silver. It is then washed and heated with hydrochloric acid to remove any magnetic iron ore that may be present; after which the ore is to be treated with nitro-hydrochloric acid diluted with an equal bulk of water to prevent the iridium generally present from being dissolved. The proportions of acids are 150 parts of hydrochloric to 40 parts of nitric. Three or four days' digestion, aided by gentle heat, is necessary to complete solution. The suspended matter, generally consisting of iridium, is allowed to subside, when the solution may be siphoned off.

Ammonic chloride[1] is next added as a precipitant, and throws down the yellow crystalline ammonio-platinic chloride, which is readily decomposable by heat, yielding platinum in a finely-divided state.

The liquid from which the precipitate is obtained will still be found to contain about 11 parts of platinum, together with all the associated metals. These are all thrown down by means of a plate of zinc and washed carefully, and again dissolved in nitro-hydrochloric acid. A small quantity of strong hydrochloric acid is added to avoid precipitation of lead or palladium, when precipitation of the remaining platinum may be again effected by ammonic chloride. This precipitate will require careful washing in cold water to remove iridium, which during the process forms a double salt with the ammonic chloride.

The next stage in the operation consists in separating the metal from the ammonia salt by ignition, and, as it is important to the success of the subsequent working that the precipitate shall remain in a finely-divided state, too high a degree of heat must be avoided, as otherwise cohesion of the particles will take place. Ignition is generally accomplished by the following means: The precipitate is heated in a graphite crucible until nothing remains but the finely-divided platinum. This is powdered, should it be found somewhat lumpy, in a wooden mortar with a wooden pestle, sifted through a fine lawn sieve, and mixed with water to the consistence of a stiff paste. This is placed in a brass mould with a slightly tapering cylindrical cavity about 7 inches in length, provided with a loosely-fitting steel stopper which enters to the depth of a quarter of an inch. The mould is first oiled and set up in a vessel of water. The platinum mud is then introduced, and as it settles into the water air is displaced, and the platinum is thus made to fill every part of the mould. The water is allowed to drain, and its removal may be aided by pressure. Ultimately, however, the mould is placed in a press worked by a powerful lever, by which the mass sustains an enormous pressure, after which the plug and the column of platinum are removed by gently tapping the mould. It is then heated in a charcoal fire in order to thoroughly dry it and to burn off any adherent oil.

The next step, which depends upon the quality of welding possessed by platinum, consists in heating the porous cylinder in a blast-furnace to

[1] About 40 parts.

white heat, when it is removed, set upright on an anvil, and hammered on the ends in order to weld the particles; after which it is coated with a mixture of borax and carbonate of potash, and again heated for the purpose of removing traces of iron, which is dissolved by the mixture, the latter being removed by immersion in dilute sulphuric acid. The bar of platinum is now ready for use and may be rolled or hammered.

It may readily be surmised that so imperfect a means of obtaining a solid bar of metal as the latter part of the operation just described cannot always be relied upon for the production of a uniform and solid specimen; and, indeed, platinum prepared in this way, though of great purity, is liable to blister upon its surface, this being probably due to minute globules of air encased in the body of the ingot during the forging; which globules during the conversion of the ingot into plate by means of rollers are elongated and spread out in the form of blisters.

The dry metallurgic operations of Deville and Debray consist in heating in a reverberatory furnace about 2 hundredweight of platinum ore with an equal weight of galena (sulphide of lead). When the ore is sufficiently heated (to bright redness) portions of the galena are added and mixed with the ore by constant stirring. An equal quantity of litharge is next added in order to supply oxygen to the sulphur of the lead ore, which passes off as sulphurous anhydride, reducing all of the lead which combines with the platinum. After remaining in a state of fusion for a short time the upper portion is ladled off, and will be found to consist of an alloy of lead, platinum, and smaller portions of palladium and silver, the latter being introduced from the galena, which always contains more or less silver. The heavier metals of the platinum group, from their greater density, subside to the bottom.

Cupellation is now resorted to in order to separate the platinum from the lead. This consists of two distinct operations. The first is performed at the ordinary furnace temperature, and is continued until by loss of lead the fusing-point of the remaining alloy rises to such an extent that a state of fusion can no longer be maintained. The second and final operation is performed in an apparatus which serves the purpose of both furnace and cupel. It is formed of blocks of thoroughly-burned lime. In form it may be described as a sort of basin or concavity with a similar piece for a cover. The lower part is intended for the reception of the metal: through the centre of the upper portion or cover pass the tubes for the oxyhydrogen jet, while the lower portion is provided with a lip or spout for pouring the melted metal. The tubes which pass through the top for the transmission of the two gases are generally formed of copper, with platinum tips. The outer and lower tube carries hydrogen, while the inner and upper one carries a jet of oxygen into the middle of the flame. The tubes are furnished with stopcocks, so that the supply may be regulated. When the object is merely to fuse some scraps of platinum, the lime furnace is first put together, the hydrogen jet is lighted, oxygen is then turned on, and the interior of the apparatus soon becomes heated. The platinum is then introduced in pieces through a small hole at the side, and quickly fuses after entering the furnace.

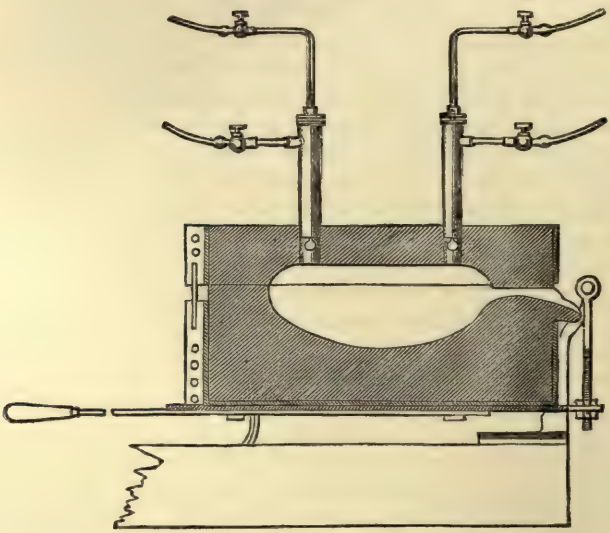
When used as a cupel the lime absorbs the impurities, and the platinum is kept in a state of fusion until all the lead is oxidized, when the

metal may be poured from the lime cupel into an ingot-mould formed of coke or plates of lime. Some difficulty may be experienced at the moment of pouring in consequence of the dazzling white surface of the molten lead. From seven to eight pounds may be melted in this way in from forty to sixty minutes.

Although such metals as palladium, osmium, gold, silver, and lead are volatilized at the intense heat used, it has been found that platinum obtained by the Deville-Debray method is not as pure as that obtained by Wollaston's plan.

Properties.—Platinum is somewhat whiter than iron. It is exceedingly infusible, requiring the flame of the compound blowpipe (oxyhydrogen) to render it fluid. In both the hot and cold states it is exceedingly malleable and ductile.[1] It is the heaviest substance in nature, its specific gravity being 21.5, and it is exceeded in tenacity only by iron and copper. No single acid attacks it, and it is unaffected by air or moisture at any temperature. It is therefore of great value in the construction of chemical vessels.

Fig. 105.



Oxyhydrogen blowpipe

At bright-red heat platinum welds quite readily, and injured vessels may be repaired in this way. In the finely-divided state, as obtained by Wollaston's process, it may be made into vessels by pressing the pulverulent metal into suitable moulds, heating and hammering to complete the welding of the particles.

[1] Wollaston, in endeavoring to substitute platinum for the spider's web usually employed in micrometers, made platinum wire finer than had hitherto been obtained. This was accomplished by forming a coating of silver upon a platinum wire and then passing it through the drawplate, after which he dissolved the silver, leaving the platinum the $\frac{1}{30000}$ of an inch in diameter, a mile of which, notwithstanding the high specific gravity of the metal, would only weigh a single grain.

Platinum possesses the remarkable property of inducing chemical combination between oxygen and other gases. Even in the compact condition it possesses this quality, as demonstrated by the familiar experiment of suspending a coil of platinum wire in the flame of a spirit-lamp, and suddenly extinguishing the flame as soon as the metal becomes entirely heated, when, by inducing the combination of the vapor of the spirit with oxygen, the wire will continue to glow. An instantaneous light apparatus has been made in which a jet of hydrogen is thrown upon a ball of spongy platinum: the latter induces combination between the oxygen condensed between its pores and the spirit-vapor, and ignition takes place.

Platinum-black, in which the metal exists in an exceedingly fine state of division, possesses this power of promoting combination of oxygen with other gases to the highest degree. In this form it is capable of absorbing eight hundred times its volume of oxygen. No combination, however, takes place between the two, the gas being merely condensed within the pores of the metal ready for combination with other bodies; hence if a jet of hydrogen be thrown upon a small lump of this powder, ignition ensues. During the operation of melting, platinum absorbs oxygen and gives it off in cooling, "sputtering" as silver does under like conditions.

The proper solvent for platinum is nitro-hydrochloric acid, the chlorine evolved being the active agent. Alloyed with silver, however, platinum will be dissolved in nitric acid, and when platinum is found in gold as an alloy it may be separated by quartation with silver.

Alloys.—Equal weights of platinum and gold afford a malleable alloy: the brilliancy of appearance characteristic of gold is, however, much lessened by the admixture. The two metals, combined in the proportions of 1 part of platinum to 9.5 of gold, form an alloy of the same density as platinum. An excess of platinum with gold yields an alloy which is infusible at ordinary furnace-heat.

The tenacity of gold is very greatly increased by admixture of platinum, while at the same time it is rendered more elastic.

Platinum and silver may be combined in all proportions, constituting alloys of greater hardness than either of their constituents, while the color is between the color of silver and that of platinum. Hot sulphuric acid will dissolve the silver from an alloy of this kind, and when 1 part of platinum is alloyed with 10 parts of silver both metals may be dissolved by nitric acid.

Platinum and mercury do not amalgamate readily, and combination can only be effected by rubbing finely-divided platinum, such as is reduced from the ammonio-chloride, in a heated mortar with mercury moistened with water acidulated with acetic acid. By this means an unctuous amalgam is obtained which has been employed in platinizing metallic objects in a manner similar to that known as fire-gilding.

The use of platinum as a constituent in alloys for dental amalgams has been almost entirely abandoned. The author found, as the result of a large number of experiments, that it rendered the alloy very brittle, and, while its presence seemed to retard amalgamation, it increased the capacity of the alloy for mercury.

Iridium confers upon platinum great hardness and tenacity; indeed,

the alloy resulting from this combination is so rigid that it is with the greatest difficulty it can be swaged into plates. It is, nevertheless, an alloy of great value to the mechanical dentist, as it affords a means of obtaining great strength in artificial dentures of the "continuous-gum" class, and it has been used in the author's laboratory since 1870 in connection with vulcanized rubber, the plate being constructed of iridio-platinum, with the teeth, single or in sections, attached by means of rubber. The swaging requires the use of the zinc counter-die, and when the ridge is very prominent it is best not to attempt to carry the plate entirely over it, rather allowing the rubber to take its place. An artificial denture constructed in this way has no superior in point of strength and durability.

Nothing but pure gold should be used as a solder in uniting two pieces of platinum or iridio-platinum. Indeed, so feeble is the union between the latter and an ordinary gold solder that two pieces united by its agency may be readily torn apart with the pliers. The addition of iridium is also of value in the construction of platinum vessels for experimental laboratory use, as the metal is thereby rendered more resistant to high temperatures and less susceptible to the action of chemicals.

Platinum combines with tin in all proportions, and the resulting alloy is hard, brittle, and more or less fusible. Between the platinoid metals and tin, at the moment of fusing together, phenomena very suggestive of true chemical union have been observed, and if tin and platinum foils be rolled together and heated under the blowpipe, combination takes place explosively. It is in consequence of this affinity that two such metals, one of which is infusible at ordinary furnace temperature, while the other is readily fusible at a low degree of heat, may with the greatest facility be melted together to form an alloy.[1]

Oxides.—Platinum unites with oxygen to form two compounds—the monoxide or platinous oxide (PtO) and the dioxide or platinic oxide (PtO_2). The first is obtained as a black powder by digesting the dichloride with caustic potash. The second (PtO_2) may be prepared by adding barium nitrate to a solution of platinic sulphate. Barium sulphate and platinic nitrate are thus formed, and from the latter caustic soda precipitates one-half of the platinum as platinic hydrate, a bulky brown powder which, when gently heated, becomes black and anhydrous. It is also formed when platinic chloride is boiled with an excess of caustic soda and acetic acid added. It combines with bases and dissolves in acids. Platinic oxide with ammonia forms an explosive compound which detonates violently at about 400° F. Both oxides of platinum are reduced to the metallic state by heating to redness.

Platinic chloride ($PtCl_4$) is the most useful salt of the metal, and is the one from which all the platinum compounds are obtained. It may be prepared by dissolving scraps of platinum in a mixture of 4 measures of hydrochloric acid with 1 of nitric acid, 100 grains of platinum requiring the presence of 2 ounces of hydrochloric acid. After complete solution the liquid is evaporated at a gentle heat to a syrupy consistence, redissolved in hydrochloric acid, and again evaporated to expel excess of nitric acid. The syrup-like fluid solidifies on cooling to a

[1] See chapter on "Alloys."

red-brown mass which is deliquescent and readily dissolves in water or alcohol.

Spongy platinum is prepared by heating the yellow crystalline precipitate obtained by the addition of ammonic chloride.

Platinous chloride ($PtCl_2$) may be formed by heating platinic chloride to a point somewhat above 450° F. A very high temperature reduces it to the metallic state.

Sulphides.—The compounds PtS and PtS_2 are produced by the action of hydrogen sulphide, or the hydrosulphide of an alkali metal, on the dichloride and tetrachloride of platinum respectively. They are both black, insoluble substances.

Discrimination of Platinum Salts.—1st. A blackish-brown precipitate, insoluble in nitric or hydrochloric acid singly, will be thrown down by the addition of hydrogen sulphide (H_2S).

2d. Ammonia or potash throws down a yellow crystalline precipitate.

3d. A brown hydrated platinic oxide is precipitated from the salts of platinum by the addition of soda, and it should be remembered that the precipitate is soluble in an excess of the soda.

4th. A deep-brown color is imparted to solutions of platinum salts by the addition of stannous chloride, but no precipitate is obtained.

Quantitatively, platinum may be separated from other metals with which it is likely to be associated by precipitating with ammonium chloride. This is added to the platinum solution, followed by a little alcohol. The precipitate is collected, washed with alcohol, and dried, when it is ready for weighing. Every 100 parts will contain 44.28 of platinum.

Iron.

Atomic weight, 56. Symbol, Fe (Ferrum).

Iron is present in nearly all forms of rock, clay, sand, and earth. It is the most widely diffused of the natural coloring ingredients, and its presence may be readily distinguished by the color which it imparts. It is found in varying proportions in plants and the bodies of animals, the blood of the latter containing about 0.5 per cent. of iron associated with its coloring matter.

Iron seems to have been known very early in the world's history, and at a remote period instruments of agriculture and war were manufactured of it.[1] Its chief ores are oxides, carbonate, and sulphides. Metallic iron[2] is met with in nature in the meteorites or metallic masses of unknown origin which occasionally fall to the earth.[3] The carbonate and oxides are the ores from which iron is chiefly obtained. Their reduction—that of the oxide especially—is exceedingly simple, and consists in merely heating them in contact with carbonaceous compounds, by which means the metal is liberated.

Properties.—Pure iron is nearly white in color, extremely soft and

[1] Archæologists distinguish a Bronze Age in prehistoric times intermediate between those of Stone and Iron.

[2] Metallic iron, though of exceedingly rare occurrence, has been found at Canaan in Connecticut, forming a vein about 2 inches thick in mica slate.

[3] Isolated masses of soft iron sometimes of large dimensions, have been found upon the surface of the earth in South America; they are supposed to have had a similar origin.

tough, and has a specific gravity of 7.8. Iron may be regarded as possessing a greater number of valuable qualities than any other metal; hence it occupies the highest place in the useful arts. Although possessing nearly twice as much strength as the strongest of the other metals, it is yet one of the lightest, and is therefore peculiarly fitted for use in the construction of bridges, ships, etc. It is rendered so ductile by heating that it may be rolled into very thin sheets or drawn into the finest wire, and yet at ordinary temperatures it is the least yielding of the metals in common use, and may always be relied upon to afford a rigid support. An iron wire one-tenth of an inch in diameter is capable of sustaining 705 pounds. It is very difficult of fusion, and before becoming liquid passes through a soft or pasty condition. Pieces of iron pressed or hammered while in this state cohere or weld together.

The fusing-point of iron has been estimated at 2900° F. It is soluble in nitric, dilute sulphuric, and hydrochloric acids, but is not much affected by strong sulphuric acid. Chlorine, iodine, and bromide attack it readily. Under certain circumstances it is not acted upon by strong nitric acid. If a piece of platinum wire be kept in contact with it, it will remain in this acid for many weeks without being acted upon. Its crystalline form is supposed to be a cube. When rolled into bars or drawn into wire it possesses a fibrous texture, upon the perfection of which much of its strength and value depends. It is the most tenacious of all the metals. At red heat iron decomposes water, evolving hydrogen, and is changed into the black oxide. It is a strongly magnetic metal, but loses this quality when heated to redness.

Iron does not oxidize in dry air at ordinary temperatures, and it may be immersed in water from which the air has been carefully excluded without change. Contact with a more electro-positive metal will also prevent oxidation. Thus, fine steel instruments are sometimes packed for exportation by wrapping in thin sheet zinc. For a description of the compounds of iron and the reagents employed in its discrimination the student is referred to Fownes's *Elementary Chemistry*.

The value of iron does not depend alone upon its physical properties, for it enters into a large number of compounds which are of great use in the arts, and its chemical relation to carbon is such that the addition of a small quantity of that element converts it into steel, harder and more elastic than iron, while a larger quantity of carbon produces cast iron, which is so fusible that many useful articles may be made of it by casting.

Steel.—Herodotus states that among the most precious gifts presented by the Indian monarch Porus to Alexander the Great was a pound of steel, the value of which at that time has been estimated at about two hundred dollars. At a later period the manufacture of steel in its application to warlike implements was carried to a great state of perfection in India and in the south of Europe.

Steel differs from iron in possessing the property of becoming very hard and brittle if, when heated to bright redness, it is suddenly cooled by being plunged into water. Steel is simply iron chemically combined with the precise amount of carbon which will produce the condition referred to, together with additional toughness. It does not, however, become decidedly steel-like until the carbon amounts to 0.3 per cent.

The hardest steel contains about 1.2 per cent. of carbon, and when that proportion is exceeded it begins to assume the properties of cast iron.

There are several processes by which steel may be produced. Bars of iron imbedded in charcoal powder in a suitable crucible or chest made of some substance capable of resisting the fire are, after several hours' exposure to heat, converted into steel, the iron taking up the requisite amount of carbon. The product of this operation is called "blistered steel," and is far from uniform either in composition or texture, as portions of the bars thus produced will be found to contain more carbon than others, and the interior to be more or less porous. For the purpose of improving its quality the bars are cut into short lengths, made up into bundles, heated to the welding-point, and placed under a powerful tilt-hammer, which consolidates each bundle into one mass. This is called "shear steel."

Fusing and casting steel is another process for the treatment of the blistered form, by which is produced the best and most homogeneous variety. It consists in fusing about 30 pounds of broken fragments of blistered steel in a plumbago crucible, the surface being protected from oxidation by glass melted upon it. When perfectly fluid the steel is cast into ingots, and when it is desirable to form a very large ingot several crucibles are simultaneously emptied into the same mould. Cast steel is superior in density and hardness to shear steel, and is the form best adapted to the manufacture of fine cutting instruments. It is, however, somewhat brittle at red heat, and much care and skill is required in forging it. The addition to it while fused of 1 part of a mixture of charcoal and oxide of manganese affords a fine-grained steel, which may be cast into a bar of wrought iron in the ingot-mould, in order that the tenacity of the iron may be an offset to the brittleness of the steel when forged together, while it affords an economical compound in the manufacture of cutting implements, the iron forming the back and the steel the edge of the instrument.

Bessemer[1] steel is produced by forcing atmospheric air into melted cast iron. The carbon, which is oxidized more readily than the iron, escapes in the form of carbon monoxide, combustion of which takes place on coming in contact with atmospheric air, and sufficient heat is thus generated to keep the temperature above the melting-point of steel during the operation. The current of air is stopped as soon as the decarburation has progressed far enough, when a quantity of white pig iron containing manganese is added to the fluid metal for the purpose of assisting the separation of gas from the melted metal. It is then ready for casting.

Some New Iron Alloys.—The combinations of iron with aluminum, chromium, copper, manganese, nickel, silicon, and tungsten constitute a class of alloys which are essentially new and are termed steels, and are usually designated with a prefix of the name of the particular element present, as nickel steel, chrome steel, etc.

ALUMINUM STEEL.—The addition of aluminum slightly increases the tensile strength, and proportionately the elastic limit, in rolled and cast steel when the amount added is not greater than 1 per cent.

[1] For other methods of producing steel see Percey's, Phillips', or Makins' works on metallurgy

CHROME STEEL.—Chromium increases the hardness, tensile strength, and elastic limit of iron, but lessens its weldability. Ferro-chrome is made by heating the mixed oxides of iron and chromium in brasqued crucibles, adding powdered charcoal and fluxes. Chrome steel is then produced from ferro-chrome by melting it with wrought iron or steel in graphite crucibles. It has been stated that the presence of chromium in steel renders it more susceptible to oxidation by exposure to air and moisture than ordinary steel. It was thought that chrome steel would admirably fill certain special requirements where great hardness and toughness is needed, as the manufacture of dental instruments, projectiles, cuirasses, etc., but there are other steel alloys coming into use which are so much better that it is probably only a question of time when it will be superseded.

COPPER STEEL.—M. Henry Schneider of Creusot, France, obtained patents for the manufacture of alloys of iron and copper and steel and copper. These alloys can be made in crucible, cupola, or open-hearth furnace. The furnace is charged with copper scraps and cast iron mixed between layers of coke, or, if a cupreous coke be employed, then the cast iron is laid in alternate layers with it, and a layer of anthracite is laid over the whole. The alloy thus formed contains generally from 5 to 20 per cent. of copper, according to the purpose for which it is to be employed, and it is remarkable for its great strength, tenacity, and malleability—properties which may still further be developed by chilling or tempering.

NICKEL STEEL.—United States patents 415,657 and 415,655, November 19, 1889, were granted M. Henry Schneider of Creusot, France, for the manufacture of alloys of cast iron and nickel and steel and nickel, respectively. The alloy of cast iron and nickel contains from 5 to 30 per cent. of nickel, and is remarkable for its great elasticity and strength—properties which admit of further development by the usual chilling or tempering.

The alloy of steel and nickel usually contains about 5 per cent. of nickel, and is especially suitable for use in the construction of ordnance, armor-plate, gun-barrels, and projectiles. Some specimens of nickel steel recently produced by Carnegie, Phipps & Co. for the U. S. Navy Department, containing $\frac{3}{16}$ per cent. of nickel, showed, when tested, the following results: Elastic limit, 59,000 and 60,000 pounds per square inch; ultimate tensile strength, 100,000 and 102,000 pounds per square inch.

It is stated that the presence of manganese in nickel steel is most important, as it appears that without the aid of manganese in proper proportions the best results could not be obtained. Nickel steel is said to be less liable to corrode in salt water than ordinary steel, which, it may be proper to observe in this connection, is more readily acted upon by sea-water than are the more impure grades of iron.

The success of the nickel-steel armor-plate at the recent test by the U. S. Navy Department, in which the nickel-steel plates alone withstood the eight-inch chrome-steel projectiles without cracking, has had a most important influence upon the manufacture of that alloy.

MANGANESE STEEL.—The maximum of strength, toughness, and hardness is probably reached in this alloy when about 15 per cent. of

manganese is added to steel. The chief obstacle to the commercial production of manganese steel is its extreme hardness. The working of some of the grades of this material by the ordinary methods is almost impossible.

Manganese steel is usually made by adding ferro-manganese to molten Bessemer or open-hearth steel. The extreme point of brittleness in this alloy occurs in specimens containing from 4 to 5 per cent. of manganese. Extremes of atmosphere, heat or cold, do not appear to affect the properties of manganese steel. When a piece of it, heated sufficiently to be seen red hot in a dark room, is plunged into cold water, it becomes soft enough to be easily filed. Hardness is then restored by reheating to a bright red and cooling in air.

Hardening and Tempering.—Hardening of ordinary carbon steel is effected by subjecting the object to extremes of temperature. The common practice is to first coat the surface of the metal with some carbonaceous substance, such as soap, to prevent scaling and oxidation of the surface. Ferrocyanide of potassium has also been used for surface-hardening. This salt contains cyanogen (C_2N_2), a gas consisting of 12 parts by weight of carbon and 14 of nitrogen. This is decomposed at the high temperature which is employed, and supplies carbon to the surface of the metal. This salt is, however, better suited to the process known as case-hardening, while in retempering dental instruments soap answers every requirement.

The metal is next heated to the point of full redness, and then suddenly plunged into cold water, oil, tallow, or mercury, or, in the case of small objects, is merely placed on a large piece of cold metal. It is thus rendered very hard, while at the same time it increases slightly in volume.

If hardened steel be heated to redness and allowed to cool slowly, it is again converted into soft steel, but it may be proportionately reduced by heating to a temperature short of redness, the proper point of which may be ascertained by noting certain colors which appear on the ground or brightened surface of a steel instrument when held over a flame. This discoloration is due to the formation of a thin film of oxide, and as the temperature rises the film becomes thicker and darker and the instrument softer. It is therefore necessary to plunge the instrument into a cold menstruum the instant the color indicating the desired degree of hardness is reached. The following table indicates the tempering heats of various instruments:

Temperature.	Color.	Use.
430° to 450° F.	Light yellow.	Enamel chisels.
470° F.	Medium yellow.	Excavators.
490° F.	Brown-yellow.	Pluggers.
510° F.	Brown-purple.	Saws, etc.
520° F.	Purple.	Wood-cutting tools.
530° to 570° F.	Blue.	When elasticity is desired.

In "letting down" or tempering dental instruments the flame of a spirit lamp may be employed, the instrument being placed in it: the flame should strike, however, some distance from the cutting end, and when the proper color reaches the end it should be thrust into water. Another

very convenient means of effecting the same result consists in heating an iron bar to redness at one end, and then fixing it in a vise. The object to be tempered is placed in contact with this until the desired tint appears.

Steel when fractured shows a fine silky appearance of the broken surface. Overheating, however, deprives it of carbon, when the fractured surface presents a coarse granular condition, showing that it is unfit for use for fine cutting instruments.

Case-hardening consists in conferring the hardness of steel upon the external surface of iron objects which are to be subjected to considerable wear, such as gunlocks, etc., and is accomplished by heating them in some substance rich in carbon (such as bone-dust, cyanide of potassium, etc.), and afterward chilling in water. The body of the piece so treated retains the toughness of iron.

Malleable iron is produced by a process the reverse of that employed in case-hardening. It consists in heating the object, usually made of cast iron (when great softness and tenacity are required), for some hours in contact with oxide of iron or manganese, by which its carbon and silicon are removed.

A steel instrument may be readily distinguished from iron by placing a drop of nitric acid upon it, a dark stain being produced upon steel by the action of the carbon.

Lead.

Atomic weight, 207. Symbol, Pb (Plumbum).

The reduction of lead is effected in a reverberatory furnace in which the broken lead ore (galena) is roasted at a dull-red heat, by which means the sulphide becomes oxidized and converted into sulphate. At this stage of the operation the contents of the furnace are thoroughly mixed and the temperature raised, which causes the sulphide and sulphate to react upon each other, producing sulphurous oxide and metallic lead.

Lead is the softest metal in common use, and may be said to be the least tenacious. In fusibility it also surpasses all other metals commonly employed in the metallic state except tin, the fusing-point of lead being 617° F. = 325° C. It is quite malleable and ductile, and will admit of being rolled into thin sheets or foil, in which form it was at one time much used in filling teeth. Its chief use in the dental laboratory consists in the formation of counter-dies.

Alloys.—Lead unites with tin in all proportions, the resulting alloys being more tenacious and fusible than either constituent. By the addition of bismuth the fusing-point is reduced below the boiling-point of water.

Lead amalgamates readily with mercury, condensation accompanying the union. The noble metals are all rendered brittle and unworkable by the presence of lead. There are some properties peculiar to alloys of lead and silver which are turned to advantage in the separation of silver from lead when it occurs as a native alloy. Lead combined with a considerable quantity of silver will remain fluid at a lower temperature than

other specimens containing a smaller percentage, thus affording an opportunity for the poorer lead to crystallize, when it is ladled out.[1]

The smallest proportion of lead in gold will greatly impair the ductility of the latter. Makins states that "Hatchett found that $\frac{1}{1920}$ of lead destroyed the coining qualities of gold." Gold reduced to standard fineness by lead is light-yellow in color and quite brittle. The contents of the dentists' gold-drawer are always liable to contamination by small pieces of lead, the latter being much used in the form of thin sheets in the making of patterns by which the gold or silver plate is cut. As the working qualities of the precious metals are seriously impaired by its presence, means should be instituted to ensure its complete removal. This may be accomplished by cupellation, or by melting the gold or silver in a crucible and adding nitrate of potassium when the point of complete fusion has been reached.

Lead and platinum, like tin and platinum, appear to possess considerable affinity for each other, and an alloy of the two can be formed at a comparatively low temperature.

An alloy of lead and platinum is very hard and brittle. With palladium also lead forms a very hard and brittle alloy.

The most valuable alloys of lead are those which it forms with tin, antimony, and bismuth, constituting solders, pewter, type-metal, etc.

Soft solders usually consist of lead and tin in various proportions. Bismuth and sometimes cadmium are added when a more fusible solder is required. Metallic tin is used alone in some cases, as in the soldering of fine utensils of tin-plate. Lead is also soldered to lead by simply melting the edges by means of a blowpipe flame. This is called *autogenous soldering*.

Soft solders are termed common, medium, or best according to the amount of tin entering into their composition. Fine or best solder is largely used for uniting objects composed of britannia metal, tin-plate, brass, etc. An alloy of 1 part of tin to 2 parts of lead is the common solder used by plumbers.

The composition of the different kinds of soft solder is given in the following table :[2]

Tin.	Lead.	Tin.	Lead.
1	10	$1\frac{1}{2}$	1
1	5	2	1
1	3	3	1
1	2	4	1
1	1	5	1

For the *discrimination* of lead the student is referred to Fownes's or other standard works on chemistry.

Copper.

Atomic weight, 63.4. Symbol, Cu (Cuprum).

Copper is a metal with which mankind has been acquainted from the most remote periods, and probably the first metallic compound employed was copper alloyed with tin (bronze), of which many relics in the form

[1] See chapter on "Silver."

[2] *Mixed Metals*, Hiorns.

of arms, ornaments, and domestic implements, evidently belonging to an early period in prehistoric times, are still to be found.[1] It is probable, however, that the production of the pure metal is an operation of a more recent date.

Copper ores are found in many parts of America and Europe. In some parts of the United States the native metal is found in immense masses many hundred pounds in weight, sometimes slightly intermixed with silver. Nothing is certainly known of the origin of these, but they are supposed to have been formed from the cupric sulphide, which by exposure to air and moisture was converted into sulphate, and then, by electro-chemical agency, reduced to the metallic state.

There are several ores which yield copper. The one most commonly employed, however, is copper pyrites, a combination of sulphide of copper and iron. The blue and green carbonates, known respectively as azurite and malachite, are beautiful minerals extensively used in Russia and Bohemia in the manufacture of ornamental objects. They contain upward of 50 per cent. of copper.

The process of obtaining copper from an ore, such as copper pyrites, may be thus briefly described: The ore is heated in a reverberatory furnace for the purpose of converting the iron sulphides into oxide. The copper, which remains unadulterated, is then heated with a siliceous sand, which combines with the iron oxide to form a slag and separates from the heavier (copper) compounds. By repeating this process the iron is finally gotten rid of, when the copper sulphide begins to decompose in the flame-furnace, parting with its sulphur and absorbing oxygen. The resulting oxide is, however, reduced by the aid of carbonaceous matter and a high degree of heat.

Properties.—Pure copper may be obtained by decomposing a solution of pure sulphate of copper in the galvanic current. If the negative wire be attached to a copper plate immersed in the solution, the pure metal will be deposited on it, and may be readily stripped off.

The chief value of copper in the useful arts is due to its great malleability, in which quality it is only exceeded by gold and silver. It fuses at about 2000° F. It expands in solidifying, and absorbs oxygen very much in the same manner as does silver under similar conditions. In tenacity copper ranks next to iron, as a copper wire of one-tenth of an inch in diameter will support about 385 pounds. Its power of conducting electricity is nearly equal to that of silver, while in the transmission of heat it is surpassed only by silver and gold. It is readily soluble in nitric acid, but in sulphuric acid only with the assistance of heat. Hydrochloric acid attacks it slowly, and in vacuo is inactive. The specific gravity of copper is 8.93. For the compounds of copper with the non-metallic elements the student is directed to Fownes's, Bloxam's, and other works on chemistry.

Amalgams.—Copper does not readily unite with mercury without the assistance of heat. There is, however, an amalgam of pure copper and mercury extensively used in Europe under the name of Sullivan's amalgam. Its preparation is as follows: Pure copper in a finely-divided state is obtained by boiling a concentrated solution of cupric sulphate

[1] The epoch marked by the use of bronze is known as archæological chronology as the Bronze Age.

with distilled zinc until the blue color of the salt disappears, when the zinc should be removed. The copper, which will be found in a pulverulent mass at the bottom of the vessel, should be washed with dilute sulphuric acid, subsequently in hot distilled water, and dried. It is then moistened with a solution of nitrate of mercury, by which means the copper becomes completely coated with mercury. The mercury is then added to it to the extent of twice the weight of copper (3 of copper to 6 of mercury). It is then rolled into small, lozenge-shaped pieces, which become quite hard, and are supplied to the profession in bottles containing an ounce or more. This amalgam possesses the property of softening with heat and again hardening, and when employed as a filling material one of the lozenge-shaped pieces is placed in a small iron spoon made and sold for the purpose, and heated over the flame of a spirit-lamp until small globules of mercury are driven to the surface, when it is placed in a small glass or porcelain mortar and rubbed into a smooth paste. Some recommend washing with a weak solution of sulphuric acid or soap and water, and lastly with clean water alone to remove the last traces of either acid or soap, and finally squeezing through chamois leather to exclude surplus of mercury, when it is ready to be introduced into the cavity. It requires several hours to harden. Mr. Fletcher says of this amalgam that "it is an absolutely permanent filling, as the copper salts permeate and perfectly preserve the tooth." It is said to be quite insoluble in the mouth. It, however, becomes intensely black, and imparts a most objectionable stain to the teeth.

According to Watts' *Chemical Dictionary*, the specific gravity of pure copper amalgams is the same after hardening as before; "hence the presence of copper in amalgam alloys lessens their contractibility."

It is said[1] that the tendency of copper amalgam to discolor may be lessened by careful attention to its preparation. The older way of preparing it was by precipitating copper from a solution of cupric sulphate, with mercury at the bottom of the vessel that contained it, by stirring the fluid with a bar of zinc; but a better way, and one now employed, is to substitute a clean iron bar for the zinc, and leave it from twelve to twenty-four hours in a jar containing the solution. The iron bar becomes covered with a dull-red flocculent precipitate of copper. When a sufficient quantity of the precipitate is formed it is collected into another jar, and well washed with a stream of cold water until it becomes quite clean. It is then ground in a mortar until it begins to amalgamate, the amalgamation being hastened by hot water slightly acidulated with sulphuric acid, which will also remove traces of iron. It should next be washed in liquor ammonia to neutralize traces of acid, and must then be thoroughly triturated in a mortar until thorough amalgamation has been effected. The amalgam should be rolled into small pellets and allowed to set for twenty-four hours before using.

The expectations of valuable therapeutic qualities in copper amalgams have not been realized. Dr. C. D. Cook and W. St. G. Elliott of London found by experiment that copper amalgams shrunk more than simple alloys of tin and silver, and the opinion seems to be gaining ground among those who have recently somewhat eagerly adopted it as a filling material that it is a very uncertain agent, and that, "whatever

[1] Mr. E. P. Collett, *British Journal of Dental Science*, April 15, 1890.

antiseptic influence it has, it does not prevent decay from beginning and progressing directly in contact with it."[1]

Alloys.—Copper unites readily with all other metals, and many of the resulting alloys are of great value in the industrial arts—of even more value than the pure metal. It is added to silver for the purpose of conferring sufficient hardness upon the latter to enable it, in the form of coin or plate, to withstand the attrition to which such articles are exposed.

The formation of a perfectly uniform alloy of silver and copper is a process attended with some uncertainty, owing to a tendency on the part of the copper to separate and pass off toward the edges as the ingot solidifies. Thus, in silver coins one portion of the piece will frequently be found to contain more copper than another.

The decimal proportions of copper and silver in standard silver (coin) of several different nationalities are as follows:

Of the United States	silver	900,	copper	100
" France	"	900,	"	100
" England	"	925,	"	75
" Indian rupees	"	947,	"	53
" Germany—Prussian thalers	"	811,	"	189
" " Prussian silver groschen	"	283,	"	717

The properties conferred upon gold by the addition of copper are similar to those imparted to silver. These have already been alluded to on page —. The decimal proportions in the gold coins of the United States, France, and Holland are—gold 900, copper 100; while English coins are composed of 916.6 of gold and 83.3 of copper. In coin-gold malleability is not greatly interfered with. Gold may, however, be rendered brittle by large proportions of copper or when the latter is impure.

Copper and platinum form an alloy, when the proportions are equal, of nearly the same specific gravity and color as gold. Copper also unites with palladium to form a light, brassy alloy. By admixture with lead or bismuth copper is rendered quite brittle. The principal alloys in which it forms a leading ingredient are brass, bronze, and German silver.

The alloys manufactured under the name of German silver or nickel silver consist usually of nickel, copper, and zinc. In some cases a little cobalt is present, and from 1–3 per cent. of lead is sometimes added when the alloy is to be used for cast work. The formulas for the composition of German silver are very numerous, but probably the best quality of the alloy is made of the following proportions:

Copper	46
Nickel	34
Zinc	20

"The German method of mixing the different metals in the formation of nickel silver, as given by Hiorns,[2] is as follows: The zinc and nickel to be used for a certain quantity of copper are divided into

[1] Dr. Howe in discussions of J. Allen Osmun's paper entitled "Some Observations on the Use of Copper Amalgams," read before the New York Odontological Society, published in the *International Dental Journal* for July, 1892. [2] *Mixed Metals*, p. 224.

three equal portions. On the bottom of a graphite crucible, capable of holding 22 pounds of the alloy, is placed a layer of copper, and upon this a layer of zinc and nickel; upon this another layer of copper is placed, and so on until all the copper is in the crucible. One-third each of zinc and nickel is retained for future addition. The contents of the crucible are then covered with charcoal powder, and the metals melted in an ordinary casting furnace. When the contents are supposed to be liquefied an iron rod is inserted, and if the whole is thoroughly fused, it is then vigorously stirred. The remaining zinc and nickel are then added in portions at a time, and the whole well stirred after each addition, a brisk fire being maintained to prevent chilling of the alloy by the freshly-added metals. After the introduction of the last portion an additional piece of zinc is thrown into the crucible to compensate for loss of zinc by volatilization. If the alloy is intended for rolling, it should be kept liquid for some time longer before casting, keeping the surface well covered with charcoal."

Aluminum bronze is formed of pure copper alloyed with from 2.5 to 10 per cent. of aluminum. It is quite malleable, and has a fine, rich golden color. Phosphor bronze is copper combined with from 3 to 15 per cent. of tin and from $\frac{1}{4}$ to $2\frac{1}{2}$ per cent. of phosphorus. Other metals, such as silver, nickel, cobalt, antimony, and bismuth, frequently enter into the composition of bronzes.

Copper in small quantities (from 5 to 7 per cent.) is said by Mr. Fletcher to confer upon amalgams the quick-setting property obtained by the addition of platinum. It is, however, considered inferior to platinum as a constituent in dental alloys; but in the absence of platinum amalgams are improved by the addition of a small proportion of copper.

It is stated[1] that an alloy of tin 10, silver 8, gold 1, copper 1 has been extensively used (in England probably) under the names of gold amalgam and platinum amalgam.

Hydrogen sulphide (H_2S) and ammonium sulphide, when added to a copper solution, afford a brownish-black cupric sulphide.

Caustic potash throws down a pale-blue precipitate of cupric hydrate, which changes to a blackish-brown anhydrous oxide on boiling. Ammonia also gives a blue precipitate, soluble in excess, affording a deep purplish-blue solution.

Potassium ferrocyanide gives a red-brown precipitate of cupric ferrocyanide. It may also be detected in very weak solutions by placing a drop on a slip of clean platinum-foil. A point of zinc is then dipped in so as to touch the foil, and instantly a spot of reduced copper appears.

A green line is imparted to the oxidizing flame of the blowpipe when a copper salt is heated in it. It also communicates a green tint to borax when heated with it.

There are several methods which may be advantageously employed for the estimation of copper. The operations of the dentist, however, are chiefly confined to the examination of amalgam alloys. The alloy should first be acted upon by nitric acid; silver, if present, may then be recovered in the form of chloride; after which the copper may be precipitated from the remaining solution either as oxide, sulphide, or in the

[1] Fletcher.

metallic state. When attempting the estimation of an alloy a qualitative examination should first be made, and if the solution to be examined is found to contain no other metal whose oxide is thrown down by caustic potassa, an excess of that agent is to be added. In the resulting precipitate, when boiled, washed, dried, and weighed, every 100 parts may be estimated as containing 79.85 per cent. of metallic copper.

When hydrogen sulphide or ammonium sulphide is employed as the reagent, the resulting cupric sulphide is usually oxidized by nitric acid, and again precipitated by potassa, so as to estimate as oxide.

The estimation as metallic copper is accomplished as follows: Place in the solution contained in a platinum dish a piece of zinc, adding also a little hydrochloric acid. The electrolyzing action instantly commences, and continues until the solution is colorless and the zinc completely dissolved. The finely-divided metallic copper will be found at the bottom of the vessel. This is to be well washed, dried, and weighed.

ZINC.

Atomic weight, 65.2. Symbol, Zn.

The ancients were undoubtedly acquainted with an ore (probably cadmia[1]) which they employed with copper to form brass. Many objects of ancient manufacture, analyzed at different times, have been found to contain zinc.[2] The extraction of the metal itself, however, is probably a modern discovery.

Metallic zinc is never met with in nature. The principal ores are the red oxide, the sulphide of zinc (blende), and the native carbonate (calamine). The latter is the most valuable of the zinc ores, and is preferred for the extraction of the metal. It is first roasted to expel water and carbonic acid, then mixed with fragments of coke or charcoal, and distilled at a full red heat in an earthen retort. Carbon monoxide escapes, while the reduced metal volatilizes and is condensed by suitable means.

Properties.—Zinc is a brittle, crystalline metal, with a density varying from 6.8 to 7.2. Until about the commencement of the present century the valuable property possessed by this metal, of becoming quite malleable between 248° and 302° F., was not known; hence prior to that discovery it was but little used in the industrial arts. Between these degrees of heat it may be rolled or hammered without the least danger of fracture. Sheet zinc of commerce is manufactured by this means, and it retains its malleability when cold. Zinc fuses at 773° F. (below red heat). At a bright-red heat it boils and volatilizes, and if heated in air combustion takes place, during which it unites with the atmospheric oxygen with brilliant incandescence. At 410° F. zinc is so brittle that it may be powdered in a mortar.

Alloys.—With mercury, zinc forms an exceedingly brittle amalgam. The two combine in the cold state, but union is greatly facilitated by heating. Zinc is occasionally employed as a constituent in dental alloys. An amalgam has been suggested, the proportions of which are "ap-

[1] An ore used by the ancients containing cadmium and zinc.

[2] Phillips made a number of analyses of such objects, all of which showed the presence of zinc.

proximately" given as—tin, 50 odd; silver, 30; gold, 5 to 7; zinc, 2 to 4; and recent experiments with it have proved so satisfactory that it has to a certain extent taken the place of platinum in dental amalgams.

Added to silver in the proportion of 2 of zinc to 1 of silver, a nearly white malleable alloy results.

The color of gold is heightened by the addition of zinc, while its malleability is greatly impaired. Makins state that gold rendered standard by zinc is a greenish-yellow, brittle alloy, with a specific gravity above the mean.

Combination between zinc and platinum or palladium may be effected at a comparatively low temperature, and it is accompanied by evolution of light and heat. It is stated that an alloy of 16 parts of copper, 7 of platinum, and 1 of zinc closely resembles 16-carat gold, is quite malleable, does not tarnish in air, and is capable of resisting cold nitric acid.

Zinc and lead mix with each other to a very limited extent. If equal parts of the two metals are melted together and allowed to cool, they will be found to have separated into two layers, the upper, and consequently the lighter, one, zinc, retaining 1.2 per cent. of the lead, while the lower layer consists of lead alloyed with 1.6 per cent. of zinc. The necessity of carefully keeping these two metals separate in all moulding operations in the dental laboratory will readily be appreciated, as a failure to observe precaution in this direction will be followed by vexatious consequences. If by accident lead becomes mixed with the zinc used for dies, the lead, by its greater specific gravity, will settle to the bottom and fill up the deeper portions of the sand matrix representing the alveolar ridge, the most prominent part of the die. This may not be discovered until an attempt to swage is made, when the die will be found to be totally unfit for the purpose. In such cases the mixed metal should be discarded and new zinc substituted.

Zinc and tin unite in all proportions without difficulty. Alloys of zinc and tin are frequently employed in casting dies for swaging plates. Richardson[1] gives a formula for an alloy consisting of zinc 4 parts, tin 1 part, which, he states, fuses at a lower temperature, contracts less in cooling, and has less surface hardness than zinc. Fletcher, however, states that all alloys of zinc and tin are superior to zinc alone for dies. The impression from the sand he believes to be much finer, and the shrinkage in cooling greatly reduced. Zinc 2, tin 1, is given as the best proportion.[2] Makins states that zinc and tin, when combined in equal proportions, form a white, hard alloy, not very malleable or ductile, which is capable of being worked as readily as brass.

Zinc and copper unite in various proportions to form many different grades of brass, known respectively as pinchbeck, Manheim gold, similor, Bath metal, Prince Rupert's metal, Muntz's sterro, Gedge's and Aich's metals. German silver and Chinese alloys known as pakfong and tutenag are also alloys of zinc and copper, with the addition of nickel.

Dies and Counter-dies.—Zinc is the metal most commonly employed in the formation of dies for swaging plates, and is superior to any of its alloys.[3] Another important application of zinc is in the formation of

[1] *Mechanical Dentistry.* [2] *Practical Dental Metallurgy*, p. 69.

[3] The author has not found the alloys of zinc and tin to be, in any respect, superior to zinc alone for dies.

counter-dies. The die is placed in the iron ring when a Bailey flask is employed, or invested in the moulding sand and then surrounded by a suitable iron ring in the old-fashioned way. The zinc is then heated and poured in upon the zinc die just at the moment of complete fusion. Should the metal be accidentally allowed to remain on the fire too long, and thus reach a higher temperature than is necessary, it should not be poured until it begins to solidify at the edges. The belief seems to be pretty general that melted zinc cannot be poured upon a zinc die without causing cohesion;[1] but if the necessary precaution regarding the proper temperature at which the metal is poured is observed, it is impossible for union to take place, and when cool the die and counter-die will separate quite as readily as though the latter was of lead. It frequently occurs that the zinc die and lead counter-die are totally inadequate to bring a plate (particularly if the latter is of platinum-gold or iridium-platinum) into perfect adaptation to all parts of a model, especially where the palatal arch is very deep and the rugæ are prominent.

The zinc counter-die is also of especial service in partial cases where a number of teeth remain. These are cut off from the plaster model previous to moulding within one-sixteenth of an inch of the margin of the gum, so that a sufficiently distinct impress may be made in the plate to serve as a guide in filing the latter to fit around the natural teeth.

Where the swaging is likely to be attended with difficulty, at least three sets of dies and counter-dies should be made. The most imperfect of these should be furnished with a lead counter-die, and used as a preliminary die upon which to start the plate. The next in quality may be used with the zinc counter-die, and the nearest perfect of the three, with a lead counter, reserved as a finishing die. When the plate, by means of the horn or wooden mallet and some preliminary swaging with a light hammer, has been made to assume somewhat the form of the die, and has been carefully carried past the stage when pleating or wrinkling of the plate is likely to occur, it should be trimmed to the proper dimensions, annealed, and placed between the die and zinc counter-die, and at first gently tapped with a hammer until the die passes well into the counter-die, when one or two sharp blows with a heavy hammer, either upon the die or its counter, will carry the plate into perfect adaptation to all parts of the former. Some slight compression, however, of the prominent points of the die is likely to occur in the use of the zinc counter, so that it will be necessary to anneal and give the plate two or three sharp blows between the finishing die and its lead counter-die; after which it will be found to perfectly fit the mouth without any attempt to compensate for contraction of the zinc.[2] It will be seen that the zinc counter-die is not intended to supersede, but is merely used as an adjunct to, the lead counter, and there is probably no better means of carrying the plate to the deep parts of the model and of obtaining a sharp, well-defined impress of the rugæ and prominent parts of the model.

[1] If the melted metal be poured, at a temperature of 800° F., upon a die having a temperature of 70° F., the fused zinc by contact with the iron ring and by radiation will lose heat enough to cause its temperature to fall far below the fusing-point, and it will probably not impart to the die more than 400° F.

[2] The subject of shrinkage of zinc when used for dies in forming metallic plates has been fully referred to on pp. 77 and 78.

Compounds of Zinc.—The oxide and the chloride are the compounds of this metal most frequently employed by dentists. The first forms the chief ingredient in the plastic filling materials known as oxychlorides and oxyphosphates. Zinc oxide is a white powder, the product of the combustion of the metal. It turns yellow on heating, but resumes its pure white color on cooling.

Chloride of zinc, prepared by acting upon the metal with hydrochloric acid or by heating metallic zinc in chlorine, is a fusible deliquescent substance quite soluble in water and alcohol.

Oxychloride of zinc, the well-known filling material, consists of a powder and a fluid. The first is prepared by various formulæ. One in common use is as follows: Grind together, in a mortar, borax 2 grains, fine silex 1 grain, oxide of zinc 30 grains. When thoroughly mixed these are placed together in a small crucible and heated to bright redness. This is called the *frit*, and when cool requires grinding to again reduce it to a pulverulent state. It is then thoroughly mixed with three times its weight of calcined oxide of zinc. The fluid usually employed with the powder consists of chloride of zinc diluted with water in the following proportions: Deliquesced chloride of zinc, 1 ounce; water, 5 or 6 drachms. The oxyphosphate powders are similar mixtures.[1] The fluid, however, is prepared by dissolving in pure water some glacial phosphoric acid, and then evaporating until the solution attains the consistence of glycerin.

The presence of zinc in solution is distinguished by the following reactions: a white precipitate soluble in excess of the alkali is obtained by the addition of caustic potash, soda, or ammonia, and zinc is distinguished from all other metals by ammonium sulphide, which precipitates white sulphide of zinc, insoluble in caustic alkalies.

Aluminum.

Atomic weight, 27.4. Symbol, Al.

Occurrence.—Aluminum is never found in the metallic state. Of all the metals, the sources of alumina are the most numerous and abundant. Its chief combinations are with silicon and other bases. These substances, undergoing atmospheric changes, form clays and soils, which under the influence of heat and moisture become fruitful. It would seem that its presence is not necessary to the maintenance of animal or vegetable life, since no traces of it have been found in either. Some of the compounds of aluminum are quite unattractive, but there are a number possessing great hardness and extraordinary beauty. The following, with their formulæ, are a few examples of the latter:

Ruby[2]	Al_2O_3.
Sapphire	Al_2O_3.
Garnet	$(CaMgFeMn)_3Al_2Si_3O_{12}$.
Cyanite	Al_2SiO_5.

[1] Oxide of zinc 200 parts, silex 8, borax 4, ground glass 5, levigated under water to ensure complete admixture, then dried by evaporation, calcined at a white heat, and pulverized, have been found to be equal in durability and working qualities to any of the numerous oxyphosphates now in the market.

[2] Corundum, the ruby, and the sapphire have the same chemical formula, Al_2O_3.

As early as 1760, Guyton de Morveau called the substance obtained by calcining alum *alumina*. Lavoisier, sixteen years later, suggested the existence of metallic bases of the earths and alkalies, and alumina was thought to be an oxide of a metal which was called aluminium; and thus it was named long before it was isolated.

In 1807, Sir Humphrey Davy tried to decompose alumina by means of an electric current, and again to reduce the metal by vapor of potassium, in both of which experiments he failed.

In 1827, Wöhler isolated the metal by decomposing aluminium chloride by potassium. The metal first isolated by Wöhler was a gray powder, taking under the burnisher the appearance of a highly polished metal. Later, in 1845, Wöhler obtained the metal in small malleable globules by making a vapor of aluminum pass over potassium placed in platinum vessels, and from these specimens he was able to determine the properties of the metal with some degree of accuracy.

The credit of the reduction of aluminum in a state of purity and the determination of its true properties belong to H. St. Clair Deville, who in 1854 brought it from the rank of a mere laboratory curiosity to that of the useful metals.

In 1854 the emperor Napoleon III., in the hope that aluminum might be used in the construction of armor and helmets for the French cuirassiers, authorized experiments on a large scale to be carried on at his own expense. In 1855 the emperor put the necessary funds at the disposal of Deville, whose experiments were continued for four months, the result being that in August of the same year aluminum was placed on the market in Paris at 300 francs a kilo.

The first article known to have been made of aluminum was a baby-rattle for the infant prince imperial, for which purpose it was well fitted on account of its sonorousness; but application of the metal to the manufacture of cuirasses and helmets was decided to be impracticable, and the idea was abandoned.

Reduction of Aluminum.—A mixture of the double chloride of aluminum and sodium or the double fluoride of aluminum and sodium (cryolite) is heated to redness with the metal sodium, when energetic chemical action takes place, during which chloride of sodium is formed and the metal aluminum separated.

Aluminum may be separated by electrolysis. The electric current from a ten-cell-battery, provided with carbon poles, is passed through the fused salt. The metal appears at the negative pole in large globules.

In 1882 the cost of aluminum was materially lessened by inventions of Webster of Birmingham, England. This inventor's method of producing the metal consisted in reducing sodium compounds in cast-iron pots from a fused bath of caustic soda. By this means the yield of sodium is much greater than by the method of Deville, while the temperature required in the operation is considerably less.

In 1859, Mr. Charles M. Hall of Ohio obtained letters-patent for an electrolytic method which is superior to any that preceded it. The principal feature of this process is the electric decomposition of alumina suspended or dissolved in a fused bath of the salts of aluminum, the current reducing the alumina without affecting its solvent. Mr. Hall

has succeeded in producing the metal aluminum as an article of commerce at $2 per pound.

Aluminum is nearly the color of new zinc. It is very malleable and ductile, and admits of rolling into thin sheets or it may be drawn into fine wire. It is highly sonorous, and has the power of conducting heat and electricity in about the same degree as silver. It is only two and a half times heavier than water (four times lighter than silver). Its specific gravity is 2.46, and it melts at a red heat.

Aluminum does not oxidize in air, and is not attacked by sulphur compounds. It is not attacked by strong nitric acid, and is insoluble in dilute sulphuric acid, but it may be readily dissolved in either dilute or strong hydrochloric acid, which is its true solvent. The metal is easily dissolved in solutions of caustic potash or soda.

As the result of the invention of the electrical furnace of the Messrs. Cowles of Cleveland, Ohio, aluminum bronze is made directly from corundum (Al_2O_3). Twenty-five pounds of the crushed ore is mixed with about 50 pounds of copper and 12 pounds of a mixture of charcoal and electric-light carbon, and placed in a rectangular box of firebrick lined with limed charcoal to prevent loss of heat by radiation and to protect the firebrick from disintegration. The charge is surrounded on all sides by a layer of charcoal to prevent the alloy from being contaminated with calcium from reduction of the lime present. The cast-iron slab forming the cover of the furnace is then securely luted on, and the current from a powerful dynamo-electric machine is passed into the furnace by means of two large electric-light carbons which pass through the ends of the furnace and into its contents. It requires about five hours of exposure to the intense heat afforded by the electric current to reduce the aluminum from its ore. When the furnace has cooled sufficiently the product of the reduction will be found to consist of about 50 pounds of a copper alloy containing from 15 to 35 per cent. of aluminum, which may be brought to the usual 10 per cent. standard of aluminum bronze by remelting it with the proper proportion of copper.

The reaction which takes place in the process, which is aided by the intense heat of the electric current, is probably as follows: The carbon unites with the oxygen from the corundum, forming carbon monoxide; a small percentage of the aluminum remains free, mixed in small particles with the charcoal, while the greater portion unites with the copper to form the alloy. Nearly all the oxide is reduced and the charcoal is changed to graphite. Some of the aluminum unites with carbon to form the carbide of aluminum. The fusing-point of 10 per cent. aluminum bronze is somewhat below that of pure gold.

Aluminum may be melted in an ordinary clay crucible. No flux need be used. Borax is not only useless, but is actually hurtful, as aluminum readily attacks the glasses. Biederman[1] recommends dipping the scraps which are to be melted together in benzine before putting in the crucible. Should any of them be contaminated with solder, it may be removed by immersing in nitric acid, which does not act upon the aluminum.

Annealing.—Aluminum may be softened by heating to redness and chilling suddenly by dropping into water. Richards recommends rub-

[1] *Aluminum: its Properties, Metallurgy, and Alloys,* Richards.

bing the piece to be annealed with tallow and then heating until the fat is carbonized, when at the moment the last trace of black disappears from the metal it may be dropped into water.

Alloys.—Aluminum forms alloys with nearly all the metals. That with copper [1] is the most important, and presents a closer resemblance to gold than, perhaps, any other alloy. It is used for articles of jewelry, for mountings of astronomical instruments, and for making balance-beams.

German dentists are now using aluminum bronze as a base for artificial dentures. Professor Sauer, in a paper on the application of this alloy to dental purposes, says "that in the proportion of Cu 900 to Al 100 it oxidizes but superficially in the mouth, and is as strong and resistant to attrition as 18-carat gold ; it may be swaged as easily as 20-carat gold, but it must be annealed frequently, and it is necessary to carry the heating almost to whiteness, for if the bronze be merely heated until it assumes a dark-red color it remains as hard as before." He also gives the point of fusion of the alloy as above that of 18-carat gold, so that 14- or 18-carat gold solder alloyed with copper may be used upon it without difficulty. Although the alloy is highly recommended by many German dentists, the author does not hesitate to express the opinion that it will not find favor in this country.

The following solders are well adapted to aluminum bronze :

1. Hard Solder for 10 per cent. Aluminum Bronze.

Gold	88.88 per cent.
Silver	4.68 "
Copper	6.44 "
	100.00 per cent.

2. Medium Hard Solder for 10 per cent. Aluminum Bronze.

Gold	55.00 per cent.
Silver	27.00 "
Copper	18.00 "
	100.00 per cent.

3. Soft Solder for Aluminum Bronze.

Copper, 70 per cent. Tin, 30 "	Brass	14.30 per cent.
	Gold	14.30 "
	Silver	57.10 "
	Copper	14.30 "
		100.00 per cent.

Aluminum with tin and zinc forms a brittle alloy, and with silver it yields a hard though workable compound. Aluminum amalgamates with mercury by the assistance of heat, and at the boiling-point of mercury the solution is very rapid.

Aluminum may be made to unite with mercury by the intervention of a solution of caustic potash or soda. If the surface of the metal be well cleaned or moistened with the alkaline solution, it is immediately melted by the mercury ; but the affinity of the aluminum for oxygen is greatly increased by the state of fine division, so that the amalgam when

[1] Aluminum bronze—alloy of copper with 5 per cent. of aluminum.

exposed to the air soon becomes covered with a white excrescence, which Watts found to be pure alumina.

Aluminum is employed in the manufacture of very small weights, such as the milligramme of the metric system—a use to which, in consequence of its exceedingly low specific gravity, it is particularly well adapted.

Its lightness, strength, and resistance to oxygen and the sulphur compounds are properties which would seem to point to this metal as a suitable substance as a base for artificial teeth. The readiness, however, with which it is attacked by alkaline solutions renders it unfit for use in the construction of a permanent artificial denture.

Aluminum, notwithstanding its extreme lightness, may be cast with great exactness. The late Dr. J. B. Bean, who patented a process for casting aluminum, succeeded in producing castings of exquisite fineness. Indeed, it may be stated that Bean succeeded in overcoming all the physical difficulties encountered in the effort to render aluminum available in prosthetic dentistry, but its susceptibility to the action of alkaline solutions finally compelled him to abandon it.

Dr. C. C. Carroll of Meadville, Pa., has devised a means of casting aluminum which, while much simpler than the method of Dr. Bean, affords results equally good. The metal is melted in a plumbago crucible (see p. 476) having the form of a thick-walled cylinder closed at one end, which serves as a bottom. A channel is formed within the wall of the crucible, one orifice of which terminates within at the side close to the bottom. Starting from the orifice, the channel rises in the crucible wall near the top, making a sharp return upon itself, and descends in a parallel course after the manner of a siphon, and makes its exit at the base and near the side of the crucible. Here it terminates in an iron nipple that fits into a corresponding socket in the gateway of the moulding-flask. A cylindrical plug of soapstone which fits the open mouth of the crucible is provided with a central tube of brass, to the free end of which is connected by a short length of rubber tubing a large rubber bulb. When the metal has been brought to a state of fusion the crucible is connected by means of the iron nipple at its base with the gateway of the flask, which has been previously heated to redness, and the soapstone plug is inserted in the mouth of the crucible. Compression of the air at this point by means of the rubber bulb forces the fluid metal out of the crucible through the syphon-like channel into the mould, filling the most minute lines and affording an exceedingly fine casting. Carroll makes the somewhat extraordinary statement that he has found a means of controlling the contraction of the metal, together with its tendency to disintegrate from exposure to the fluids[1] of the mouth, by the admixture of other metals. Richards, in his valuable work on aluminum, states that to overcome the difficulties of contraction and corrosion by the fluids of the mouth Dr. Carroll adds "a little copper, which, he says, decreases the contraction, while the addition of some platinum and gold renders it unalterable in the mouth."

Aluminum may be cast upon plain teeth with comparative safety, provided the metal is prevented from overlapping the necks of the teeth. But when gum-teeth are employed, either single or in sections, their fracture is almost certain to follow the contraction incident to the cooling

[1] Demonstration before dental class University of Pennsylvania.

of the metal. Specimens of Dr. Carroll's work have fully proved this, and it was the one difficulty which finally defeated Dr. Bean's efforts by compelling him to cast his plate separate from the teeth; for, if it had been practicable to cast the metal directly upon block-teeth without danger of fracture, the denture would have lasted for at least six or eight years; but the necessity of attaching the teeth to the plate by another metal so hastened disintegration that a few months only were necessary to render the piece useless.

There are two methods which have been employed in the construction of artificial dentures of this metal. The one most frequently resorted to consists in merely swaging a plate in the ordinary way. A number of countersunk holes are then made along the part covering the top of the alveolar ridge as a means of fastening the teeth, which are attached with rubber or celluloid. Sets of teeth made in this way have been known to do good service for eight or nine years, but they showed unmistakable evidence of the action of the oral fluid. In the second method the plate is cast, but disintegration in this case progresses with much greater rapidity. As the plate is cast separate from the teeth, and the latter are afterward attached by means of tin or an alloy of tin and aluminum, it is probable that the galvanic action incident to the presence of the two metals greatly hastens dissolution of the plate.

For some time the difficulty of soldering aluminum prevented the metal from being applied to useful purposes. The solder recommended for general use in the manufacture of articles of ornamentation is composed of copper, 4 parts; aluminum, 6 parts; zinc, 90 parts. The use of this requires some skill and experience. At the moment of fusion small aluminum tools are used, the friction of which is necessary to induce adhesion. Borax cannot be employed as a flux, as it is liable to attack the metal and prevent union.

Another method of uniting two pieces of aluminum with ordinary solder, in conjunction with silver chloride as a flux, has recently been recommended by F. J. Page and H. A. Anderson of Waterbury, Conn. The finely powdered fused silver chloride is spread along the lines of junction, and the solder is melted with a blowpipe or other device. The union thus obtained is said to be perfectly strong and reliable.[1]

The following alloys are also used as solders in unalloyed aluminum articles of jewelry:

	I.	II.	III.	IV.
Zinc	80	85	88	92
Aluminum	20	15	12	8

In soldering with these alloys a mixture is used as a flux consisting of 3 parts copaiba balsam, 1 part Venetian turpentine, and a few drops of lemon-juice. The soldering-iron is dipped into the mixture.

Mr. Wm. Frismuth of Philadelphia recommends the following solders for aluminum, with vaselin as the flux:

Soft Solder.

Pure Block Tin	from 99 to 90 parts.
Bismuth	" 1 " 10 "

[1] *Chemical News*, iv. 81.

Hard Solder.

Pure Block Tin	from 98 to 90 parts.
Bismuth	" 1 " 5 "
Aluminum	" 1 " 5 "

Schlosser[1] recommends two solders containing aluminum as especially suitable for dental-laboratory use:

Platinum-aluminum Solder.

Gold	30 parts.
Platinum	1 "
Silver	20 "
Aluminum	100 "

Gold-aluminum Solder.

Gold	50 parts.
Silver	10 "
Copper	10 "
Aluminum	20 "

O. M. Thowless has patented the following solder for aluminum and method of applying it:

Tin	55 parts.
Zinc	23 "
Silver	5 "
Aluminum	2 "

The silver and aluminum are first melted together; the tin and zinc are then added in the order named. The surfaces to be soldered are immersed in dilute caustic alkali or a cyanide solution, and then washed and dried. They are next heated over a spirit lamp, coated with the solder, and clamped together; small pieces of the solder being placed at the points of union, the whole is then heated to the melting-point. No flux is used.

The only oxide of this metal is alumina (Al_2O_3). It is prepared by mixing a solution of alum with excess of ammonia. The resulting precipitate (aluminum hydrate) is of a bulky, gelatinous character, and requires to be calcined at a high temperature; after which it may be described as a perfectly white powder, soluble in caustic potassa or soda, and not readily acted upon by acids.

Corundum and emery are nearly pure alumina. The ruby and sapphire are also transparent varieties of alumina in a crystalline state, their brilliant colors being due to oxide of chromium.

The only known sources of corundum until 1869 were a few rivers in India, where it occurred in crystals having the form of the double six-sided cone. Its cost at that time was from twelve to twenty-five cents a pound. Since that date, however, it has been discovered in inexhaustible quantities in Georgia, North Carolina, and Pennsylvania. At present it can be bought at the mines at $10 per ton.

(For the *discrimination* of the salts of aluminum see any of the recent works on chemistry.)

[1] Richards.

TIN.

Atomic weight, 118. Symbol, Sn (Stannum).

The metal *tin* has been known for probably three thousand years. It is found in all parts of the world, chiefly as oxide. In reducing the ore it is first powdered and roasted to free it of sulphur and arsenic. It is then exposed to a high temperature with charcoal, and the metal is thus liberated.

Pure tin is white in color and is perfectly soft and malleable. It has a density of 7.3, and its fusing-point is 458.6° F. (237° C.). It is but slightly acted upon by air, but when heated much above its melting-point it oxidizes freely, and is converted into a yellowish-white powder—the well-known polishing putty. The action of nitric acid upon tin is to convert it into a white hydrated dioxide. It is dissolved by hydrochloric acid, assisted by heat, and forms stannous chloride. Nitro-hydrochloric acid acts upon tin with much energy, converting it into stannic chloride.

Alloys.—Tin is readily dissolved in mercury. With silver it forms a malleable alloy, which is considerably harder than tin. The late Dr. Bean used tin alloyed with a small percentage of silver for lower dentures, which he cast directly upon the teeth after the ordinary cheoplastic method.

Alloys of tin and silver, in which the former is slightly in excess, are much used as amalgam alloys. Tin 10, silver 8, gold 1, is also frequently employed in filling teeth ; and tin 10, silver 8, gold 1, copper 1, has, according to Fletcher, been largely used as "gold-and-platinum" amalgam. It is stated that from 5 to 7 per cent. of copper has the property of replacing platinum in amalgams, conferring the quick-setting quality claimed for platinum.[1]

Dr. G. F. Reese has formed an alloy for a base for artificial dentures composed of 20 parts of tin, 1 of gold, and 2 of silver.[2] This is cast directly upon the teeth, the process being similar to the cheoplastic method.

The alloys which have been used in the cheoplastic process are chiefly composed of tin, silver, bismuth, and, in some instances, cadmium and antimony.

According to Makins, gold and tin form a malleable alloy,[3] and gold reduced to standard by pure tin retains its malleability.[4]

Tin and platinum in equal proportions afford a hard and quite brittle alloy, fusible at a comparatively low temperature. When it is remembered that the fusing-points of these metals almost represent extremes of temperature, it would seem that their union must be attended with difficulty, but, as has already been stated,[5] it is probable that some affinity exists between the two, as platinum is readily dissolved by and with the fused tin.

[1] F. Fletcher. [2] *Alloys and Amalgams chemically Considered*, J. Morgan Howe, M. D.

[3] A precipitated alloy of gold and tin, having the form of a black powder, may be formed by acting upon a concentrated solution of trichloride of gold with stannous chloride.

[4] The author has found that the color and the general working qualities of gold are greatly impaired by admixture with small quantities of tin.

[5] See chapter on "Alloys."

With palladium, tin is said to form a brittle alloy.

With lead, tin forms the chief part in the alloys used for soft soldering, and in the compounds known as pewter and britannia metal. Tin solders are composed of 2 parts of tin to 1 of lead, pewter consists of 4 parts of tin to 1 of lead, while britannia metal is formed by the addition of small quantities of antimony and copper.

Alloys of tin and lead are harder and tougher than either metal singly, and they are more fusible than the mean of their constituents. The addition of bismuth to such an alloy lowers the melting-point to a remarkable degree, and the fusing-point is still further reduced by the addition of cadmium. Thus, an alloy composed of 15 parts of bismuth, 8 of lead, 4 of tin, and 3 of cadmium fuses at 145° F. (= 63° C.).

Dr. C. M. Richmond uses a fusible alloy in crown- and bridge-work which he states is as hard as zinc, and can be melted at 150° F., and poured into a plaster impression without generating steam. The formula of this alloy is as follows:

Tin	20 parts by weight.
Lead	19 " "
Cadmium	13 " "
Bismuth	48 " "

The following fusible-metal alloys are also suitable for the purpose:

Tin.	Lead.	Bismuth.	Melting-point of alloy, Fahr.
1	2	2	236°
5	3	3	202°
3	5	8	197°

Dr. George W. Mellott of Ithaca, N. Y., to whom is due the credit of having introduced the use of fusible metal and the compound called "moldine" into bridge-work, uses an alloy of—

Tin	5
Lead	3
Bismuth	8

Moldine, of which Mellott forms his matrix for casting, is a compound of potter's clay and glycerin.

The alloy known as "Wood's metal," occasionally employed by dentists in replacing teeth on vulcanite plates, is composed of 7 parts of bismuth, 6 of lead, and 1 of cadmium, and fuses at 180° F. (= 82° C.) —a temperature much below the boiling-point of water. In replacing a broken tooth by means of Wood's metal the usual dovetail is cut in the rubber plate with a fine saw, the tooth is fitted to its place, and the fusible alloy is packed in with a spatula heated in a spirit-lamp.

Lead 75, tin 5, and antimony 20 parts is the composition of the best quality of type-metal.

With copper, tin affords a number of very useful alloys. Bell metal is formed of 78 parts of copper to 2 of tin. Gun metal is formed of 90 per cent. of copper to 10 per cent. of tin. Speculum metal is formed of 6 parts of copper, 3 of tin, and 1 of arsenic.

Babbitt metal, named after Isaac Babbitt of Boston, Mass., is an alloy consisting of 9 parts of tin, 10 parts of copper, used for journal-

boxes (*vide* patent 1839). Many modifications have since been made in this alloy, but the term is still applied to any white alloy employed in the construction of bearings, to distinguish it from the "bronzes" and "brasses."

Mr. Fletcher recommends an alloy of copper 4 pounds, Banca tin 96 pounds, regulus antimony 8 pounds. This alloy is said to be nearly as hard as zinc, while its shrinkage is much less. These qualities, together with the low temperature at which it fuses, entitle it to a place in the dental laboratory for the preparation of dies and counter-dies.

Dr. L. P. Haskell recommends the formula tin 72.72, copper 9.09, antimony 18.18.

Bronze is an alloy of copper and tin, and sometimes zinc. It is affected by changes of temperature in a manner precisely the reverse of that in which steel is affected, becoming soft and malleable when quickly cooled, and hard and brittle when allowed to cool slowly. The art of making bronze was practised before any knowledge of the working of iron existed, and it was used at a very early period in the manufacture of weapons.

Commercial tin is liable to contain minute quantities of lead, iron, copper, arsenic, antimony, bismuth, etc. Pure tin may be precipitated in crystals by the feeble galvanic current excited by immersing a plate of tin in a strong solution of stannous chloride. Water is carefully poured on, so as not to disturb the layer of tin solution. The pure metal will be deposited on the bar of tin at the point of junction of the water and the metallic solution.

Perfectly pure tin may also be obtained by dissolving commercial tin in hydrochloric acid, by which it is converted into stannous chloride. After filtering, this solution is evaporated to a small bulk and treated with nitric acid, which instantly converts the stannous chloride into stannous oxide. This is thoroughly washed and dried, and exposed to red heat in a crucible with charcoal. A button of pure tin will be found at the bottom of the crucible.

Pure tin in the form of foil is frequently used in filling teeth, for which purpose it doubtless ranks next to gold. The foil is also employed in connection with non-cohesive gold in filling approximal surfaces of cavities in bicuspids and molars. Two sheets of foil, one of gold and the other of tin, are placed together and made into mats or cylinders. These are carefully packed against the cervical margins of the cavity. The frequent failure of ordinary gold fillings at this point has led some practitioners to entertain the theory that between the tooth-substance and the gold there is galvanic action, to which the lime salts of the tooth yield, and that by the combination of two metals, whether tin and gold or amalgam and gold, the galvanic action is confined to the metals, the tooth-substance being thus protected.

The appearance of a filling formed of tin and gold would seem to confirm this theory, as it soon becomes dark in color, and presents a surface resembling amalgam, but it effectually protects the margins from decay.[1]

Tin, having but slight affinity for sulphur, is largely used in the

[1] Prof. James Truman, *Report of Proceedings of Odontological Society of Pennsylvania*, November, 1881.

formation of models in the construction of vulcanite dentures, and tin-foil forms the best coating for plaster casts in the vulcanizing process.

The manufacturers of miscellaneous rubber articles do not use plaster in forming the matrix in which the rubber is packed before vulcanizing, having long since discovered that contact with plaster lessens the toughness and elasticity of the indurated rubber: they therefore form every matrix of sheet tin, which is placed in a suitable iron box and covered tightly with dry powdered soapstone (steatite).

Dr. J. S. Campbell, who introduced the vulcanizer known as the "New Mode Heater," described a means whereby all parts of the matrix contained in the flask in constructing rubber dentures could be covered by sheet tin, so that after vulcanizing and the removal of the sheet tin or foil the surface of the rubber would be found to be smooth and highly polished, and, if the "waxing up" had been carefully done, little or no filing and scraping were needed. The method demonstrated by Dr. Campbell possessed precision and saved labor, and it is to be regretted that it was not generally adopted by mechanical dentists, who have not improved to any extent upon the slovenly methods employed in 1858, when indurated rubber was first employed in dental practice.

When tin-foil is used as a coating for plaster casts in rubber work, the foil may be removed with the finger-nail if the surface of the plaster model was smooth and hard, and this condition of the plaster surface can be obtained by using nothing as a coating for the plaster impression but sandarac varnish, and carefully avoiding the use of oil or solutions of soap as a means of separating the impression from the model. If, however, in consequence of the roughened surface of the plaster cast the tin-foil adheres so tenaciously that it cannot be removed except by means of a solvent, hydrochloric acid is the only one that will accomplish that end without injury to the rubber. Both nitric and nitro-hydrochloric acids should be avoided, as they attack indurated rubber with more or less energy.

Lower vulcanite dentures may be loaded with tin to give them additional weight, and by lessening the quantity of rubber prevent the occurrence of porosity during the process of vulcanizing.

Solvents.—Tin is readily dissolved by either of the three mineral acids. Sulphuric acid converts it into stannic sulphate. Tin dissolved in hydrochloric acid forms stannous chloride. By the action of dilute nitric acid tin is not dissolved, but is converted into stannic oxide, which settles to the bottom of the vessel as a white powder. This, when rendered anhydrous by heating to redness, affords the well-known polishing-powder called "polishing putty."

Chlorides.—There are two chlorides of tin—stannous chloride or protochloride of tin ($SnCl_2$), and stannic chloride or bichloride of tin ($SnCl_4$). Stannous chloride is prepared by dissolving tin in hydrochloric acid, the action being assisted by gentle heat. Stannic chloride is obtained by dissolving tin in nitro-hydrochloric acid (aqua regia). These two compounds of tin are employed in the preparation of purple of Cassius, in which process stannous chloride is added to a mixture of stannic chloride and trichloride of gold (see page 109).

(For other compounds of tin see works on chemistry.)

Discrimination.—Tin is detected before the blowpipe by fusing the

compound under examination on charcoal with sodium carbonate, when a bead of the metal is obtained. From a tin solution caustic potash and soda precipitate a white hydrate, soluble in excess. Ammonia affords a similar precipitate, not soluble in excess. Hydrogen sulphide and ammonium sulphide throw down a dark-brown precipitate of monosulphide. Trichloride of gold added to a dilute solution of stannous chloride causes a purple precipitate (purple of Cassius).

CHAPTER III.

PRINCIPLES OF METAL WORK.

SHEET-METAL WORK IN DETAIL; THE MANUFACTURE OF TAPS, SCREWS, NUTS, THREADED WIRES, BANDS, REGULATING APPLIANCES, ETC.—SPECIAL TOOLS AND APPLIANCES REQUIRED.

By C. L. GODDARD, A. M., D. D. S.

PLATE OR SHEET METAL.

As the refining, alloying, and working of metals and forming an ingot have been described in other parts of this work, the present chapter will begin at that point.

The Ingot.—After an ingot of metal has been moulded it should be forged for three purposes—to test its malleability, to reduce its thickness, and to bevel one edge slightly.

Sheet-metal or Plate.—Although an ingot may be reduced to plate by hammering, it is a slow and laborious process. It is better to use a rolling-mill, such as is shown on page 37.

The mill should be provided with long handles, and both ends of the rolls should be adjustable by means of one screw. A geared mill is much easier to work than one without gearing.

After annealing, the bevelled edge of the ingot should be introduced between the rollers, which should be adjusted so as to only slightly compress it as the handles are turned. For rolling a large, thick ingot two persons are required, one for each handle. The rolls should be brought nearer together, the ingot passed through again, and the process repeated, with occasional annealing, till it is reduced to plate of the desired thickness. If plate is desired wider than the ingot, it should be rolled till the desired width is obtained, then annealed, reversed, and rolled crossways till reduced to the desired thickness. If, in rolling, the plate curves, showing that one edge is thinner than the other, screw the rollers nearer together on the thicker side of the plate and roll again, repeating the process till the plate is reduced evenly. If this precaution is neglected and the plate merely reversed and rolled again, it will be rolled thinner on the edges than in the middle, and will crumple.

For bands for regulating appliances plate is best rolled from round wire. This gives a long, narrow ribbon, the edges of which are less liable to tear than the edges of cut plate.

The thickness of metal plate and also the size of wire are measured with a plate or wire gauge (page 38). There are several of these, but

the one used most by dentists is the American standard wire gauge, called generally the Brown & Sharp (or B. & S.) gauge. All numbers of plate and wire in this chapter refer to this gauge, and are generally marked B. & S., as band ribbon No. 32 to 36 B. & S. gauge, or wire No. 16 or 18 B. & S. gauge, etc.

Materials for Regulating Appliances.

Quite a variety of materials are needed for regulating appliances, for bands, caps, screws, nuts, springs, clasps, plates, hoods, etc.

Materials for such use should not be deleterious to the teeth in any respect, and should be inconspicuous. Some should be soft and pliable, others hard and rigid, others elastic. They should not corrode nor tarnish in the mouth. It is not always possible to obtain all the desirable qualities in one material, hence it is sometimes necessary to sacrifice one quality for another that is more important. Some metals or alloys that corrode or tarnish readily in the mouth have qualities of such importance that less important ones must be ignored. Utility must not be sacrificed to appearance.

For bands the most suitable metals are platinum, combined platinum and gold, and German silver. Platinum is best, because it does not corrode and may be soldered with pure gold without a flux. It is soft and pliable, and may be easily bent around a tooth and burnished accurately to fit the contour. To some patients the color is objectionable, hence for the anterior teeth the writer prefers a combination of platinum and gold made for crown-work, platinum coated with gold on one side. This has all the advantages of platinum in strength, and all the advantages of gold in appearance. It may be soldered with 20-carat solder. Coin gold or 22-carat is also good for bands, but must be used thicker than platinum to obtain the requisite strength.

German silver was introduced for regulating appliances by Dr. E. H. Angle. It is strong, elastic when rolled without annealing, yet very soft and pliable when annealed. It may be soldered with gold or silver solder. It has the disadvantage of discoloring easily, though the more highly it is polished the less it discolors. It may be protected by electroplating with gold or nickel, but, unless the plating is quite thick, discoloration will still take place.

Vulcanite is used as in prosthetic work for making plates for attachment of ligatures, rubber bands, springs, etc. It has been replaced to a very great extent by appliances attached directly to the teeth.

Tubes.—For use on posterior teeth or on the lingual surface of anterior teeth nothing is superior to German silver. For use on the anterior teeth tubes may be made of coin or 22-carat gold, about No. 30.

Bars may be made of German silver or clasp gold according to the position in the mouth, and soldered with gold or silver solder.

Wire may be made of clasp gold or German silver. Both of these materials are made elastic by drawing through the draw-plate, but annealing lessens the elasticity of the former and entirely removes it from the latter. The former retains its color well in the mouth, while the latter discolors very easily.

Piano wire is more useful than any other for springs for moving teeth. It is polished steel, and possesses more elasticity than any other wire that can be used in the mouth, yet is pliable enough to be readily bent without breaking. In some mouths it oxidizes so rapidly as to materially reduce its strength in a few days, while in others it will merely discolor slightly, but still retain its strength. It cannot be hard soldered without drawing the temper so much as to ruin its elasticity, but may be attached to other metals with soft solder without injury.

It is best to use tubes as a means of attachment, so that a new piece may readily be substituted whenever oxidation has reduced its strength or elasticity. (See Fig. 179.) Nos. 20 and 24 B. & S. G. are the most useful sizes : the former is large enough for coiled springs for spreading the arch (see Figs. 158 and 160), while the latter is suitable for springs where less force is needed. Piano-wire manufacturers use a different gauge, No. 15 piano-wire gauge corresponding to No. 20 B. & S.

Nuts may be made of German silver, clasp gold, iridio-platinum, or nickel. The relative hardness and durability increase in the order named. Clasp gold retains its color better than either of the others.

Screws may be made of German silver, clasp gold, or steel. Their strength varies in the order given. Clasp gold retains its color best. German silver retains its hardness, and will wear much longer if not annealed after drawing and screw-cutting. Although it is softened in the process of soldering, it still retains sufficient rigidity for most purposes.

Steel oxidizes so readily in the mouth that its use for screws has been practically abandoned. Nickel-plating does not entirely remove the objection, as steel will oxidize under the nickel-plating and peel it off.

Swaged caps may be made of German silver, platinum, or gold, the thickness varying from No. 30 to 36.

Tools and Appliances Needed.

It is unnecessary to describe the operation of soldering to any one who has reached this point in his professional education, but a few useful appliances and tools may be enumerated.

Fig. 106.

Soldering block.

A soldering pad or block is very easily made of plaster and fibrous asbestos, such as is used for investing. By mixing it thick it may be moulded like putty in any form desired.

A brass or sheet-iron base may be made by cutting out a round piece, slitting the edges, and turning them up. Such a block is soft enough to stick pins in to hold parts together in soldering.

Fig. 106 shows a much more convenient form. A base of plaster is made in the form of a hemisphere by making a mould from any kind of smooth ball. In use this is set in a ring of some kind or in the mould reduced to smaller dimensions. The block can thus be tilted at any angle, and both hands are left free for work.

Fig. 107 shows a very useful soldering block with clamps for holding pieces in soldering. A chemist's filter stand is of great convenience in a dental laboratory. Fig. 107 shows how one ring may be used for holding the soldering block at any convenient height. The blowpipe

Fig. 107.

may rest in another ready for use. A ring may be used to support an invested case while heating before soldering. An adjustable arm or clamp may be used to hold the blowpipe at any angle, so that both hands are left free.

The following tools are also needed: Plate shears; plate punch; flat-nose pliers; wire-cutters; round-nose pliers; clasp-benders; nippers; spring pliers, large and small; small anvil; riveting hammer; Bunsen burner; blowpipe; soldering clamps; pin vice; jeweller's saw; calipers; soldering copper; vulcanizer; flat file; half-round file; draw-

plate, round; draw-plate, square; screw-plate (Figs. 110 and 111); plate-gauge (p. 38); draw-tongs.

Drawing Wire.—As it is not always possible to obtain wire of a desired size, every dentist should know how to draw it. Draw-plates are made of hardened steel and contain a series of holes finely graded from large to small (Fig. 108).

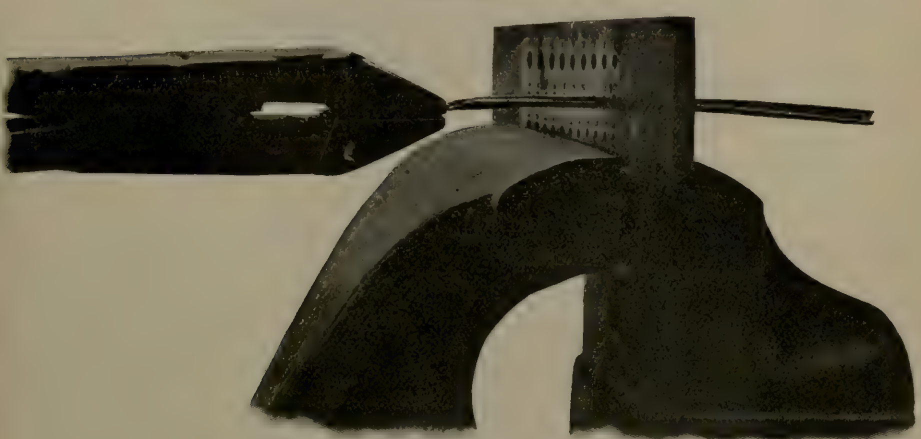
The change in size of holes from one to another should not be too abrupt. Wire may be drawn from a larger size or from an ingot moulded for the purpose. Ingot-moulds are furnished that will produce a long round or square ingot. The mould should be oiled and warmed before pouring the metal in it, so as to make a perfect ingot. After cooling the ingot should be reduced in size by forging. The square ingot is most easily reduced by holding it on a smooth anvil and hammering the sides alternately. Some care and practice is necessary, as the ingot cannot be well drawn out unless its square shape is preserved. It should be annealed frequently. Having thus reduced the ingot to a size that will enter the largest hole in the draw-plate, hammer the corners slightly to make the square an octagon.

Large and strong draw-tongs are needed, and those should be selected which have short jaws and long handles, not less than eight or ten inches in length, so that they can be grasped with both hands.

The end of the ingot or large wire must be pointed, so that it can enter the next smaller hole in the draw-plate, and project at least a quarter of an inch, so that it can be readily seized by the draw-tongs. Fasten the draw-plate in a vise and apply oil or beeswax in each hole.

Seize the projecting end of the wire or ingot, and with a quick motion draw it through the hole. Repeat the action with successive holes,

Fig. 108.



annealing frequently, till the wire is reduced to the desired size. The action of drawing hardens the wire and gives it elasticity. If it is desired to retain this elasticity, it should be annealed as little as possible during the process, and not at all afterward. If it is desired to solder

such a spring of German silver to another appliance, soft solder should be used, as the heat necessary for hard solder will destroy the elasticity.

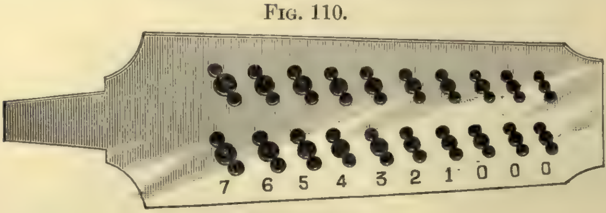
Tubing or Tubes.—Tubing is made by means of a draw-plate like wire. Having made a ribbon of the width and thickness desired, cut one end tapering, curl it slightly, and draw it through the largest hole in the draw-plate. The diameter of this hole should not be much less than the width of the ribbon. The edges will be curled slightly, and the operation should be repeated with successive holes till the edges of the tube are in contact (Fig. 108). The tube may then be still further reduced in size, the same as wire, unless the plate selected was so thin that the edges slide over each other instead of making a butt joint. For making a tube to fit any desired size of wire or screw the width of the strip should be a little more than three times the diameter of the wire or screw: No. 30 B. & S. G. plate is thick enough for tubes for most of regulating appliances. If a thread is to be cut in the tube, heavier plate should be used.

Taps and Dies.—For cutting large screws taps are used which are in sections, so that the thread may be cut slightly at first, and then

FIG. 109.

deeper by screwing the sections nearer together (Fig. 109). In cutting threads in a nut a tapering tap is first used, next another with parallel

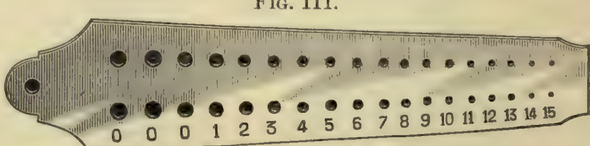
FIG. 110.



Cut screw plate.

sides, but smaller than the screw which is to fit; then a tap is used of the full size.

FIG. 111.



Jam screw plate.

This is necessary in steel and other hard metals or alloys, but with the softer ones the threads for both nuts and taps may be cut full size at first.

Sectional dies are seldom made small enough for dentists and jewellers' use, but screw-plates are provided with holes of different sizes, resembling draw-plates, except that the holes are screw cut. These are known as cut plates or jam plates according as they actually cut a V-shaped spiral groove or produce it by pressing into the surface. (See Figs. 110 and 111.)

The most efficient tap for dentists' use is a compound instrument combining a drill and a tap. It is readily made from an old excavator, one with a long handle preferred (Fig. 112). First draw the temper;

Fig. 112.

Combined drill and tap.

then, by rotating the instrument in the left hand while the end rests in a notch in the file-block of the bench, file it round for a distance of about five-eighths of an inch from the end.

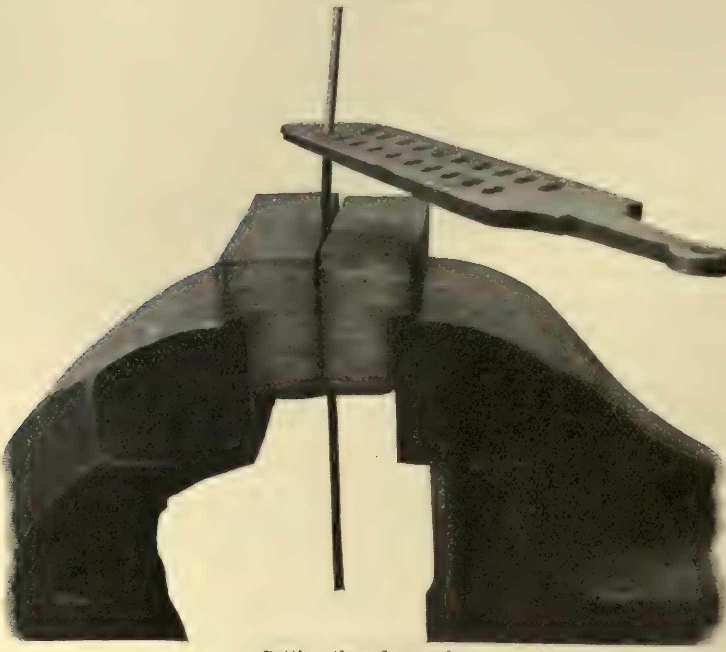
For one-fourth of an inch or more from the end the size should be such that the instrument will fit loosely the first tap-hole above the one selected in the screw-plate. For a space of one-fourth of an inch above that the instrument should be of a size to enter snugly the second hole above, and be slightly indented by the threads as it is screwed in the first hole above. Flatten the lower one-fourth of an inch and shape the end as usual for a spear-pointed drill. Cut the desired thread in the second one-fourth of an inch of the instrument. To do this well, fasten the screw-plate in a vise, and, holding the instrument at right angles, screw it slowly into the tap desired. Oil the instrument and turn it back and forth, gradually advancing it as the thread is cut. The die-plate is so hard and the annealed steel is so soft that the tap should be made without special difficulty. To temper the tap heat it to a cherry red to a distance of three-quarters of an inch from the end and plunge it in ice-water; this makes it extremely hard and brittle.

To draw the temper and make the instrument tough as well as hard, first brighten one side, then heat the end in the Bunsen or alcohol flame till the drill portion is reduced to a straw color, the tap to the slightest blue obtainable, and the shank above the tap to a spring-blue color. The drill point should be properly shaped by grinding. (See Fig. 112, showing bevelled cutting edges.) Grind the tap triangular or square.

Cutting Threads on Wire.—Select a wire which will fit loosely the second hole of the screw-plate above the size desired, or draw wire for the purpose. In the bench vise place two blocks of hard wood, and grasp the wire so as to leave about a quarter of an inch exposed (Fig. 114). File the end slightly pointed, put on a drop of oil, apply the screw-plate so that the point of the wire will enter the countersunk side; press slightly and revolve the plate in the direction indicated by the thread about one turn; revolve it back about half a turn, then forward again. By this time the thread will have caught sufficiently to hold without downward pressure. Work the plate forward and backward, advancing a little each time till the plate has run down to the wooden blocks. Unscrew the vise, raise the wire a little, and proceed as before. By thus exposing only a slight portion of the wire at a time a less amount of it is

subjected to strain, and it is less likely to bend or break. The softer the wire the more readily will the thread be cut, and the harder it is the more

Fig. 113.

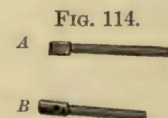


Cutting threads on wire.

care must be taken to advance the die-plate only a little at each turn, keeping the wire well lubricated.

It is well to make a screw several inches long, from which pieces may be cut off as needed. Taper the cut end slightly, as the thread is liable to injury from the shears or nippers.

Fig. 114.



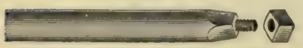
Cutting thread on wire: *A*, square-head screw; *B*, round-head screw.

A square end may be filed on the screw to fit a watch-key, or, if a larger head is needed, screw on a square nut and solder it (Fig. 114, *A*).

If a round head is needed, solder a piece of tubing on the screw at any position desired, and drill holes through it at right angles for the insertion of a pointed instrument for turning it (Fig. 114, *B*). In most appliances the screw is stationary and the nut turned.

Nuts.—The following is Dr. C. S. Case's description of his method of making nuts: "The nuts are made of five-cent nickels, which are found to be of proper quality and the thickness to be easily cut and withstand every desired force, while they suffer no oxidation in the mouth that retards them from readily gliding upon the screw. Saw the nickel in halves, and mark it into squares a little larger than the required size of

Fig. 115.



Case's guide in making nuts.

the nut. These are again cross-marked or punched in the centre for a guide to the drill. At the other end of the tap (or on an excavator handle) I make a screw the length of the nut with an abrupt shoulder, and square the shank the required size of the nut. (See Fig. 115.) This when tempered quite hard will be found a valuable and almost indispensable adjunct to the finishing of these exceedingly small nuts." Screw the roughly-shaped nut against this shoulder and file to the size and shape.

Dr. Matteson's method of making nuts:[1] "In regard to making these nuts for irregularity cases, I have found cutting them out of solid nickel and German silver plate, to be drilled, tapped, and squared, a very tedious process. The process may be greatly simplified by first drawing tubes of platinized silver (1 part platinum and 2 parts silver), soldering the joint with 20-carat gold, then drawing through a 'square-hole' draw-plate, inserting piano wire in the tube, thus making a square tube with a round hole, then sawing off enough for a nut" (Fig. 116).

FIG. 116.

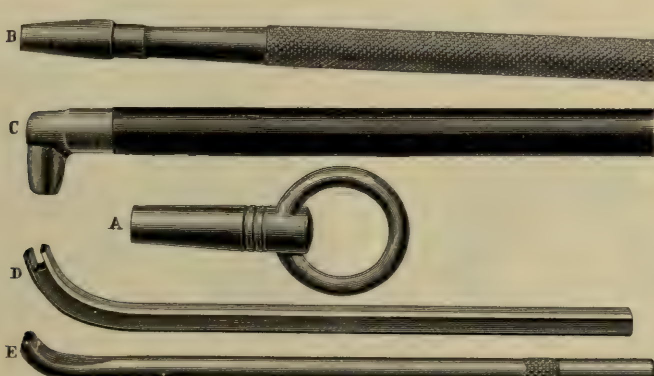
Square tubing for nuts.

German silver may be used instead of platinized silver, but is not as hard. It is not necessary to insert piano wire in the square tube in drawing. Even if the opening is reduced very small, all that is needed is enough to guide the point of the drill in enlarging it.

To make the nut, saw off a short piece of the square tube, and hold it in the vise. With the drill and tap shown in Fig. 112 enlarge the hole in the centre and cut the thread. In doing the latter work the tap from left to right, advancing a little each time till the thread is cut through the length of the nut. It is as easy to make a long nut as a short one, and the greater the number of threads in a nut the better will it hold and the longer will it last.

Keys for fitting the square ends of screws may be made by selecting

FIG. 117.



Keys and wrenches.

a watch-key or small clock-key (Fig. 117, *A*) to fit, cutting off the handle, and fastening it to a socket handle with shellac (Fig. 117, *B*). To do this fill the socket with powdered shellac, heat the key enough to

[1] *Review*, vol. iv., 1892, p. 566.

soften or melt the shellac, and press it to place. The key may be fastened with soft solder as follows: First brighten the inside of the socket and outside of the key; apply to each dilute chloride of zinc (tinner's "acid"); melt small pieces of solder in the socket till nearly full; heat the key and press into place. Pure tin may be used for soft solder in these cases. A right-angled key may be made by filing a slot in the end of a handle, squaring the key-shank, and fastening with either hard or soft solder (Fig. 117, *C*).

A wrench may be made by filing a slot in the end of a flattened instrument and bending to any desired angle (Fig. 116, *D* and *E*).

Apparatus Employed.

Plates.—For making a simple vulcanite plate to fit against the lingual surfaces of the teeth an impression should be taken in plaster, though modelling compound will do in some cases. By making a large vacuum chamber many of these simple plates can be retained by atmospheric pressure. Although plates have been superseded in a great degree, they are not only useful in a number of cases, but in some cases are better than anything else.

Advantages.—Plates by their contact with a greater number of teeth, and also with the palatine portion of the alveolar ridge, distribute their anchorage more than any other appliance; they are easily constructed.

Disadvantages.—On account of impaction of food under a plate it is more uncleanly than any other form of regulating appliance, hence necessitates very frequent visits to the dentist. In many cases, however, plates may be so constructed as to be advantageously removed by the patient for cleansing.

Fig. 118 shows the simplest form of a plate for moving a tooth lingually.

Fig. 119 shows a similar one for moving all the incisors lingually.

A tooth may be moved labially by means of rubber, compressed wood, or tape between the edge of the plate and the tooth. The edge of the plate should be made thick, and a box or dovetailed space may be cut in it, with inserted cone bars to retain the rubber or wood (Fig. 120). This is one of the oldest appliances on record.

Fig. 118.

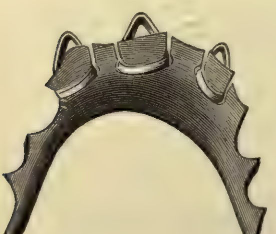
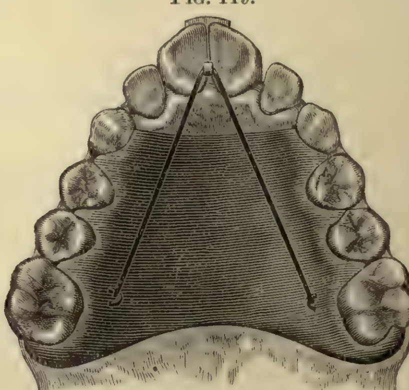


Fig. 119.



By boring two small holes through the plate near the edge a lump of

rubber may be tied to the edge with floss silk (Fig. 121). At a second visit a thicker piece or two thicknesses of the same may be tied in place. A better plan is to enlarge the plate at that point with gutta-percha (Fig. 122).

Cut a dovetailed box in the edge with an inverted cone bur, warm a lump of gutta-percha, press it in the box, put the plate in the mouth, and press it in place. The gutta-percha will mould itself against the tooth that has moved, and thus enlarge the plate just that much. A

FIG. 120.

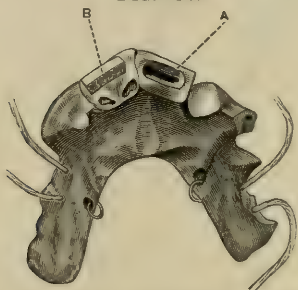


Plate with box (*A*); *B*, rubber or compressed wood in box.

FIG. 121.

Rubber tied on a plate.

piece of soft rubber may now be ligated in position as before. At the next visit of the patient the gutta-percha may be softened and pressed again against the tooth, thus enlarging the plate a second time. When the tooth has reached the desired position, it can be retained by the enlarged plate, but a better retainer is shown in Fig. 123.

Such plates may be advantageously ligated to deciduous molars or bicuspids. Two holes should be drilled through the plate from the

FIG. 122.

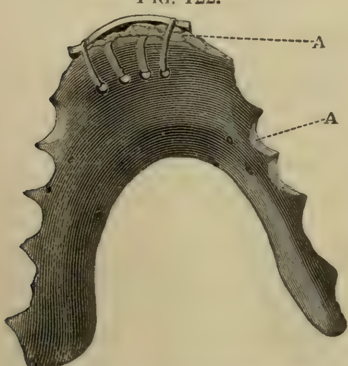


Plate with gutta-percha extension.

FIG. 123.

Author's retainer, band, and round wire.

FIG. 124.

Ligatures for securing or holding plate.

lingual surface, and should emerge at the cervico-palatine edge. The holes should not be more than one-eighth of an inch apart. Pass the ligature through the holes as shown in Fig. 124, and tie firmly around the neck of the tooth.

The plate can be advantageously used with the labial bow, as shown in Fig. 125.

The Coffin split plate is shown in Fig. 126. Plates are advantageously used for anchoring piano-wire springs, either simple or coiled, for moving

FIG. 125.

teeth in all directions (Figs. 126 and 127). The end of such spring should be flattened or bent at right angles for about one-eighth of an inch, and imbedded in the wax base-plate, with the projecting portion resting against the tooth to be moved. This projecting end will be securely held in plaster while the wax is removed and rubber vulcanized.

Bands.—The origin of the closed band for regulating appliances is lost in obscurity. It was doubtless invented independently by several different men. The writer distinctly remembers such a closed band with a hook attached having been used in rotating teeth in Grand Rapids, Mich., in 1863.

FIG. 126.

Coffin split plates.

FIG. 127.

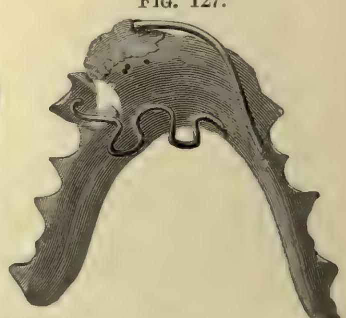


Plate and wire springs for self-protrusion—Jackson's method.

The cementing of a band on a tooth has developed a new era in regulating appliances. In the early days of orthodontia one of the most per-

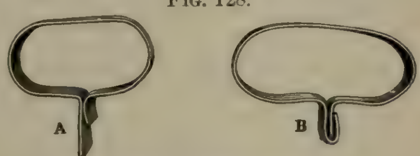
plexing problems was the attachment of appliances to the teeth. Ligatures and clasps were used, but were unsatisfactory, especially with partially erupted teeth. Sometimes pits were drilled in teeth for the ends of appliances to rest in, and sometimes these pits were deepened so that a screw could be inserted or a pin cemented in.

The invention of the closed band cemented on a tooth renders these previous methods unnecessary.

The ribbons for bands should be rolled from wire No. 13 to 16, B. & S. gauge, and so thin that they can be easily bent around a tooth, and as wide as the tooth will admit. For bicuspids and molars the thickness should not be more than No. 36, B. & S. G., while for incisors the bands may be used still thinner. After rolling the ribbon should be annealed and polished.

The simplest method of making bands is thus described by Prof. Angle: "The surface of the tooth to be banded is carefully cleaned by means of a pledget of cotton moistened in alcohol or ether. A loop of band material is then slipped over the tooth. The ends should be grasped close to the tooth with a pair of closely-fitting flat-nosed pliers and the band drawn tightly around the tooth, a strong burnisher being applied at the same time to make it conform still further with the shape of the tooth. Remove the band, which now presents the appearance shown in Fig. 128. Place a small bit of solder and borax at the junction between the ends, and carry the band in contact with the flame of the soldering lamp. After it is soldered clip the ends off, and the band is now ready for any attachment which may be made." This description applies equally to bands of German silver, platinum, or platinum faced with gold. The rubber dam should be applied before cementing a band on a tooth.

FIG. 128.

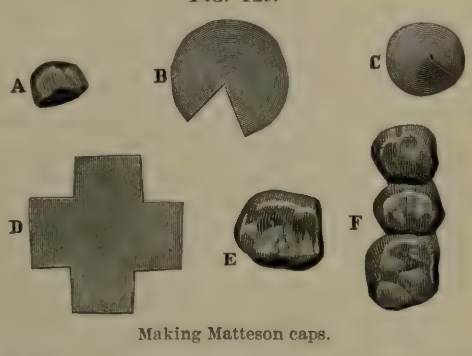


A, band fitted; *B*, ready for soldering.

In soldering such a band the projecting ends may be held in the pliers, but a simpler method is the following: Cut off one end at a sixteenth of an inch from the junction, and the other a little longer (Fig. 128, *A*). Bend the longer end over the shorter, and pinch them tightly together (Fig. 128, *B*). With light spring pliers grasp the band on the opposite side, lay a bit of solder and borax on the junction, and hold in a soldering flame.

Matteson Cap.—This is a swaged cap fitting wholly or partially over the cutting edges or grinding surface of a tooth, and extending nearly or quite to the gums or even under their free margin. Such a cap will adhere to a short or conical tooth much better than a band (Fig. 129, *A*). Take an

FIG. 129.



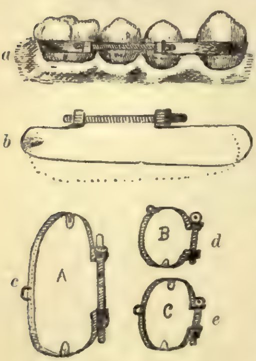
Making Matteson caps.

impression with Mellott's moldine, and make a die and counter-die of his metal. If a harder die is necessary, take an impression with Teague's impression compound or other similar material, dry it, and fill with zinc or Babbitt metal. Make a counter-die of lead or lead and tin.

In most cases a cap may be swaged from a single flat piece of metal, but it is better in some cases to cut and shape a piece partially before swaging. For a short cuspid cut a circular piece of plate having a radius equal to the longest side of the tooth ; cut a slit from periphery to centre or cut out a V-shaped piece (Fig. 129, *B*). Bend the piece into a hollow cone (Fig. 129, *C*) ; place it in the counter-die and swage. For a molar it is best sometimes to shape the plate like a Maltese cross (Fig. 129, *D*), with the centre piece as large as the occlusal surface and each arm slightly wider than the side of the tooth. After swaging the seams should be soldered with a high-grade solder. In some cases it is advantageous to make a single cap or chain of caps for several teeth, as for bicuspids and molars (Fig. 129, *E* and *F*).

Clamp Bands.—Fig. 130, *a*, shows Dr. J. N. Farrar's clamp band, which was illustrated in the *Cosmos*, Jan., 1876, and used for drawing the cuspid back. Since that time Dr. Farrar has applied the band for many other purposes and for the attachment of other appliances, to a single tooth in some cases, but more often to two or more (Fig. 130, *b*, *c*, *d*, *e*). It is constructed of 18-carat gold or platinum ribbon made by rolling out wire to a thickness of No. 30 B. & S. G. or less. To one end of the band is soldered a square nut and to the other a "smooth bone" nut. A headed screw passing through the latter engages with the former, and is tightened around the teeth by means of a wrench. The head of the screw is made square or round. If the latter, it must be perforated so as to be turned by a pin wrench (Fig. 131). To prevent the band sliding against the gums, lugs or ear-pieces are soldered on it at appropriate places and bent over the occlusal or against the inclined surfaces of the teeth. To these bands are soldered wire hooks or staples for attachment of other appliances, such as "push jacks," "pull jacks," levers, rubber bands, springs, etc. The nuts on these clamp bands are single, double, or triple, as illustrated in Fig. 131.

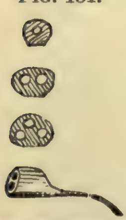
Fig. 130.



Farrar's clamp band.

Fig. 132 shows two bands adjusted with two screws working in a double nut.

Fig. 131.



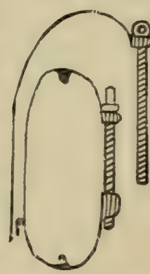
Single, double, and triple nuts (Farrar).

Angle's Adjustable Clamp Band.—From No. 36 band ribbon, as wide as the length of the crown will allow, cut a piece long enough to nearly surround a tooth. To one end solder a short screw, and to the other a short tube just large enough to pass easily over the screw. By means of a nut on the end of the screw the band may be tightened around the tooth (Fig. 133). The band should then be burnished to fit accurately. The edge should be slightly bent over the occlusal surface to

prevent the band sliding against the gum. To this clamp band may be soldered other attachments.

Bands and caps should be soldered with as high grade of solder as they will allow, so that attachments may be soldered to them with a lower-grade solder without danger of unsoldering the first seam. This, however, is not always necessary; with the skilful use of the blowpipe soldering may be accomplished on one side of the band without heating the other side to so high a temperature.

Fig. 132.



Use of double nut (Farrar).

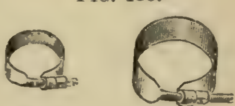
Platinum should be soldered first with pure gold, then appliances may be attached with any grade of solder they will admit. With pure gold or gold-faced platinum, solder as high as 22 carats may be used first, and lower grades afterward.

With 22-carat, or coin gold, use 20-carat solder first. With German silver use silver plate or coin silver for the first soldering, and for the second use silver solder.

Soft solder may be used for attaching piano wire or springs of any kind which will lose their temper in a high temperature.

Hooks.—The simplest way to make a hook is to form it where the band is lapped. When the band is bent around the tooth and drawn tight with the pliers, any point of junction may be selected that will be most suitable for a hook, whether on the labial or lingual surface (Fig. 134, *a*). The projecting ends may be bent at an acute angle with the band instead of a right angle, and after soldering the hook may be filed narrower than the band and the edges rounded (Fig. 134, *b*).

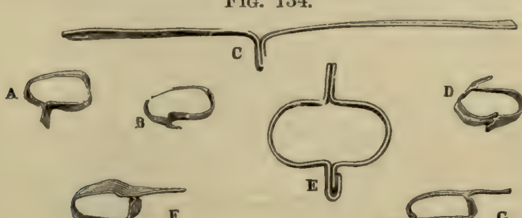
Fig. 133.



Biscupid. Molar.

If a hook is needed on both sides, make the first one by doubling the rib-

Fig. 134.

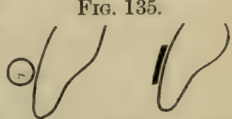


Making hooks on bands.

bon, as in Fig. 134, *c*, and soldering the junction, then bending it around the tooth as usual, and making the other hook wherever desired (Fig. 134, *d*).

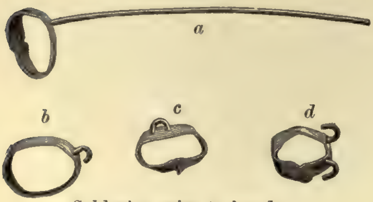
A bar or lug may be made by doubling the band for a longer distance (Fig. 134). Such a bar should be thick enough to file round or half round, as the purpose in most cases is to rest on an adjoining tooth as a retainer. A round wire resting on a tooth touches it at one point only, and can be kept clean easily, but a flat bar will retain fluids in contact with a tooth the whole width of the bar (Fig. 135).

Fig. 135.



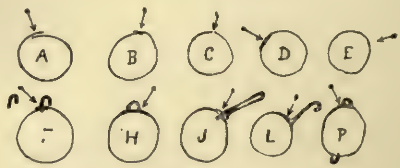
Soldering a Wire to a Band.—A wire is easily soldered to any part of a band as follows: Melt a small piece of solder on the band wherever the attachment is desired. Hold in the fingers or pliers a piece of wire three or four inches long, and rest the other on the band where the solder was fused (Fig. 136, *a*). The band may rest on a soldering block or be held in the soldering pliers. Direct the blowpipe flame on both wire and band. The wire, being smaller than the band, will be heated more quickly, and be ready to attract the solder as soon as it is melted. The surplus wire can then be cut off. The end of the wire may be stuck in a cork or piece of soft wood if the heat is communicated to the fingers, or a short piece of wire may be held in the long-handled spring pliers.

FIG. 136.



Soldering wire to bands.

FIG. 137.



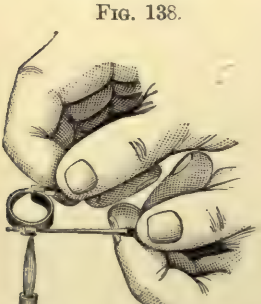
Farrar's bands, hooks, and staples.

A wire can be thus attached to a band at any angle.. A wire hook may be made by soldering the wire at right angles to the band, cutting off the surplus, and then bending the remaining portion in the shape desired (Fig. 136, *b–d*). A staple may be made by bending the loose end over on the band and soldering with a lower grade of solder.

Dr. Farrar's method of attaching a staple or a lever is to punch a hole in the band and insert one arm of the staple or one end of the lever to hold it in place for soldering (Figs. 136, 137).

To Solder a Tube to a Band.—Proceed as if it were a piece of wire and cut off the surplus. To prevent a tube opening after it is attached care must be taken to place the seam next to the band before soldering, during which process the edges become soldered also. If the seam is

FIG. 138.



Soldering a tube to a band (Angle).

FIG. 139.

Soldering regulating appliances (Farrar).

slightly flattened with a file, it is more easily kept in place while soldering. A short piece of tubing may be attached by holding it with a small steel instrument, as shown in Figs. 138 and 139, or by holding in place with a spring clamp (Fig. 140).

Another method of attaching a bar, wire, or tube is to press the edges of the band slightly into the soldering block of plaster and asbestos, and then tilt the block to an angle of about 30°, so that the tube, wire, or bar when placed in position will rest against the desired surface and be retained by gravity. Apply borax and solder to the point of contact, and direct the blowpipe flame so that the parts will be heated evenly and the solder flow to both at once. The operation is simplified if a bit of solder is first fused on the band.

Pins or pieces of piano wire may be stuck in the soldering block to hold the parts in contact.

Two bands or a series of bands may be attached at their contiguous surfaces by placing them on the teeth in the position desired, then taking an impression with modelling compound. The bands should be removed

FIG. 140.

Soldering a tube to a band.

from the teeth and placed in the impression, which should be filled with equal parts of plaster and sand, marble dust, chalk, or other suitable material. Teague's impression compound is well adapted to the purpose. When the cast is removed from the impression the bands will be found in the exact position in which they are to be soldered to each other. This may be done by melting a small piece of solder at each point of contact. Where special rigidity is needed a stiff wire may be soldered on the labial or lingual surfaces so as to unite all the bands.

FIG. 141.

Sockets.

A socket for retaining the end of a spring or screw may be made by soldering a short tube to the band vertically or at whatever angle may be best suited to the case. A hole may be punched or drilled in a band where it is lapped or the band may be thickened at any point for the same purpose. A slot may be made in the band in the same manner to retain the flattened end of a screw and prevent its turning (Fig. 141).

Partly-made Appliances.—To facilitate work when a patient is in the chair many partly-made appliances should be kept on hand, as follows:

Band material or ribbon in coils, No. 31 to No. 36, from $\frac{1}{8}$ to $\frac{1}{4}$ of an inch wide, of German silver, platinum, etc. (Fig. 143, *a*).

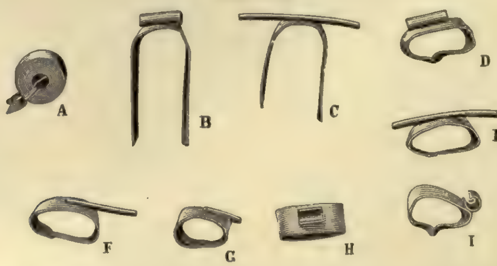
Wire.—German silver, clasp gold, and piano wire Nos. 13 to 24, also iron or copper binding wire, silver suture wire, and fine platinum wire.

FIG. 142.

Partly-made appliances.

Partly-made bands, with tube or wire bar attached (Fig. 143, B and C). By placing such a partly-made band on a tooth with tube in the position desired it may be drawn tightly with pliers and finished as in Fig. 143, D. The partly-made band C may be finished as a retainer, E or F, or the bar may be cut short enough to serve only as a hook for attachment in rotating G. The outer half of the tube may be filed or ground away to serve as a notch in which to rest a wire or bow, H. Either the upper or lower portion may be filed away so as to leave a hook, I.

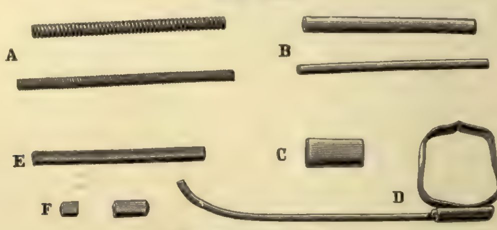
FIG. 143.



Adjustable bands (Fig. 142), either plain or with tube attached, J and K.

Screw wire (Fig. 144, A) should be kept on hand a few inches in length. Not more than two sizes will be needed in many cases. Nos. 16 and 19 B. & S. G. are convenient sizes.

FIG. 144.



Screws and tubes.

Round tubing (Fig. 144, B) of German silver for back teeth and of gold for anterior teeth should be of several sizes, to use with screws or plain wires. Some tubing should be very small for fine piano wire, No. 24 B. & S. G.

Flat Tubing (Fig. 144, C).—This is seldom needed except in short lengths, and may be made by bending a piece of the thicker band ribbon over flat-nosed pliers or a flat spatula with parallel sides, or by flattening a round tube. It is useful as a socket for a loop in the end of a piano wire, D, to keep it from turning out of position, or for a sliding bar.

Square tubing (Fig. 116) for nuts (p. 161) of one or two sizes.

Nuts, both long and short (Fig. 144, F), to fit each size of screw.

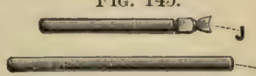
Rubber tubing, from $\frac{1}{16}$ to $\frac{1}{4}$ inch, *g* (Fig. 161);
Floss silk, previously washed;
Twisted silk and linen thread;
Tape for wedging;
Compressed wood;
Jack-screws, partly made, with long sheath, which may be quickly shortened to suit any case in hand (pp. 171 and 172);
Talbot springs (p. 174);
Matteson springs (p. 174).

Forces Applied.

Forces.—For applying intermittent force the screw is more useful than any other appliance. It is used for pushing and pulling. A pushing screw is generally known as a jack-screw, and a pulling screw as a "drag-screw."

The Angle jack-screw is the simplest and easiest to make. Having decided on the length needed, cut off a piece of screw wire a little shorter and fit it with a nut. Flatten one end by hammering, so as to spread it out wide. In some cases it is desirable to file a notch in the flattened end. Select or make a piece of tubing of such a size that the screw wire will pass in it easily without binding. Flatten one end of the tube or solder in it a short piece of wire and file it to a point. Insert the screw in the tube, and the jack-screw is complete (Fig. 145). In use one end is inserted in a socket or hole in a band attached to a tooth, and the other in a slot in a similar band. Sometimes it is best to solder either the tube or the screw to a band or some other appliance. (See Figs. 154, 155). This jack-screw may be of any length, from $\frac{1}{4}$ inch to 2 or 3 inches.

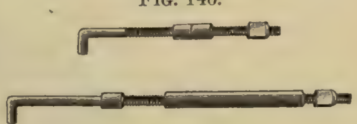
Fig. 145.



Angle's jack-screw.

Angle's *drag* or *traction screw* is simply a wire bent into a hook at one end and screw cut at the other, with a nut attached, No. 17 or 18 B. & S. G. In use one end is hooked into a tube attached to a band and the other passed through a tube on another band. Turning the nut will draw the teeth toward each other. (See Fig. 146.)

Fig. 146.



Angle's drag-screw.

Farrar's Push- and Pull-jacks.—Figs. 147–153 show various push- and pull-jacks as made by Dr. Farrar. Fig. 147 shows a fish-tailed

Fig. 147.

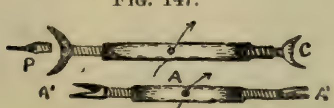
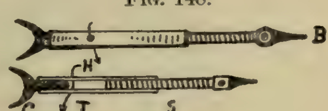


Fig. 148.



jack. A fish-tailed screw engages in one end of a screw tube. A fish-tailed wire enters loosely in the other. The tube is turned by inserting a pointed instrument in the hole drilled for that purpose.

Fig. 148 shows a spindle-end jack-screw similarly constructed, except that the fish-tailed piece is soldered in one end of the tube.

Fig. 149 shows what Dr. Farrar calls a nut-jack, used in construction of his clamp bands: the eye is made by soldering a short piece of tubing on the screw and turning it spherical in a lathe. The end beyond the eye is filed square to fit a key.

Fig. 150 shows Farrar's simplest form of screw-jack, consisting of a

Fig. 149.

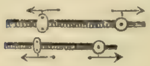


Fig. 150.

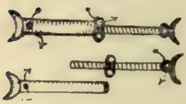
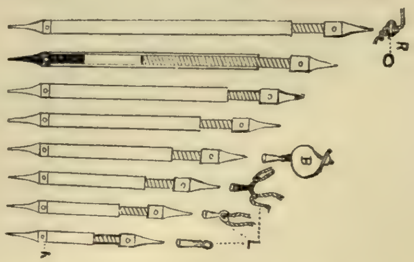


Fig. 151.



fish-tailed tube in which the screw moves loosely. On one end of the screw is an eye and fish-tail. A nut provided with eyes for turning fits on the screw and rests on the end of the tube.

Fig. 151 shows a series of spindle-end jacks constructed like those in Fig. 148, except that both tube and screw end in spindle points. One

Fig. 152.

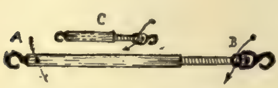
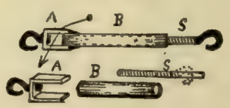


Fig. 153.



objection to these jacks is that two instruments are necessary in working them, one for holding and one for turning.

Fig. 154.

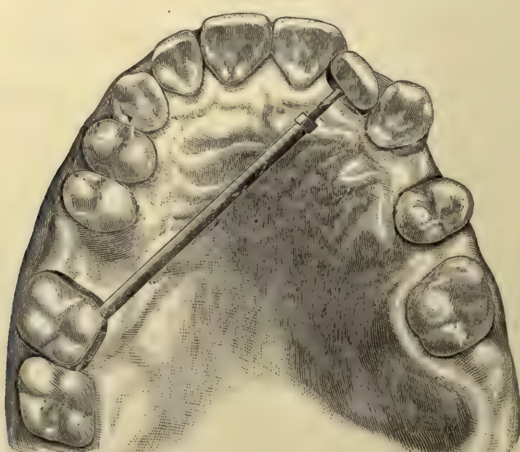


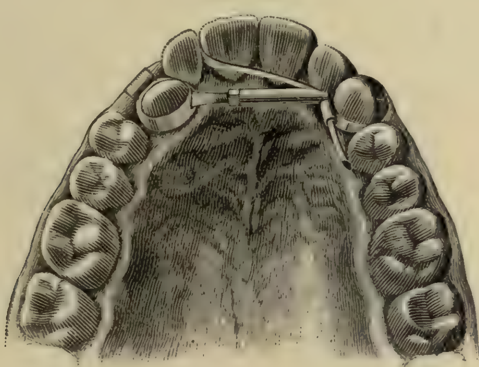
Fig. 152 shows a "cylindrical swivel screw-jack." To one end of a threaded tube is soldered a hook, and to the end of the screw is

attached a swivel ending in a hook. By turning the screw by means of a pointed instrument in the eye the hooks are drawn toward each other.

Fig. 153 shows a "barrel-turning draw-jack." A piece of plate is bent twice at right angles, *A*, and through the middle third is inserted a wire hook, *S*. It is then soldered to the extremity of the threaded barrel or tube, *B*. The hooked screw engages in this tube, which is turned by inserting a wrench in the square opening at *A*. To prevent wabbling while being operated the hooks are bent so that the draught will be in a direct line with the screw.

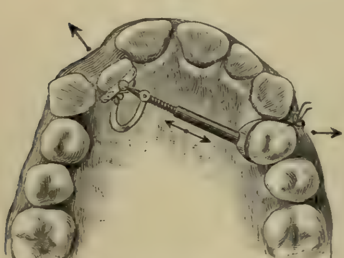
Application of the Jack-screw.—The Angle jack-screw is varied easily in length by changing the length of the tube. It can be applied in many different ways, among which are the following: Fig. 154 shows the use of a very long jack-screw, moving an incisor forward (Fig.

Fig. 155.



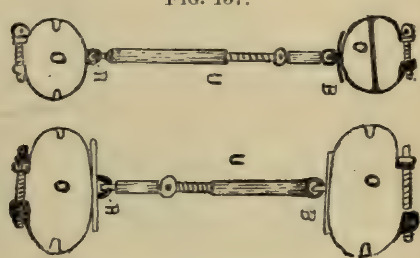
155), spreading the arch. The application of Farrar's screw-jack is shown in Figs. 156 and 157.

Fig. 156.



Application of fish-tail and spindle-jack (Farrar).

Fig. 157.

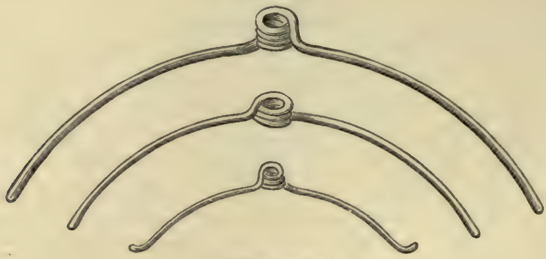


Jacks and clamp bands (Farrar).

The Talbot spring is made as follows: Drive a piece of piano wire in the bench or hold it in the vise, and around this wind another piece of piano wire by holding each end with pliers. Make two or more turns; then bend the wire at right angles along the coil to a point

opposite the beginning, then again at right angles in the same plane as the other end (Fig. 158). This latter is not necessary unless there are

FIG. 158.



Talbot spring.

several coils. Piano wire No. 15, equal to No. 20 B. & S. G., is stiff enough for most cases.

Occasionally a spring of smaller or of larger wire will be needed, but not often. German-silver or clasp-gold wire may be used for such a spring, but the elasticity is not so great.

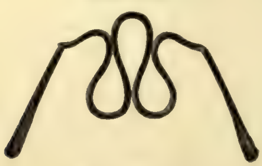
FIG. 159.

Matteson spring.

The Matteson spring differs from the Talbot spring in having two coils instead of one (Fig. 159).

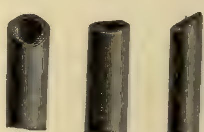
The Coffin spring, used in a split plate for spreading the arch, consists of a piano wire No. 20 B. & S. G. bent with clasp-benders into the general shape of the letter W, as shown in Fig. 160. The ends are flattened or bent at right angles for retention in the vulcanite.

FIG. 160.



Coffin spring.

FIG. 161.



Rubber tubing for bands.

For rubber bands use French tubing, from $\frac{1}{4}$ inch in diameter to $\frac{1}{8}$ or less, cutting them wider or narrower according to the amount of force needed. Bands $\frac{1}{8}$ inch in diameter are the most useful (Fig. 161). Bands made from large tubing are often so thick as to take up too much room and spread teeth apart.

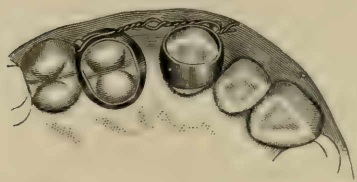
Bands may be made from rubber dam by cutting with two sizes of punches, or by first cutting a hole with a punch and trimming around it with scissors.

Compressed wood is useful for spreading teeth apart or for moving a tooth in any direction in connection with a plate or other appliance. Select a fine-grained wood and compress it laterally in a vise or with large pliers. The wood of floss-silk spools is good for the purpose. Tupelo-wood is highly recommended, being already compressed as sold by dealers. Any dry wood will swell when wet, and compressed wood will swell much more.

The swelling of pellets of cotton or of cotton tape folded in two or more thicknesses will spread teeth apart or move a tooth from some fixed position.

Rubber strips or wedges of different thicknesses may be used for the same purposes. To move one or more teeth by means of compressed wood, cotton, tape, or strip of rubber the material may be confined between the teeth or between the edge of a plate and a tooth. A box or mortise cut in the thickened edge of a plate will hold such material more securely.

Fig. 162.



Twisted ligatures of silk, linen, or wire.

Fig. 163.

Twisting wire (Case).

Fig. 164.

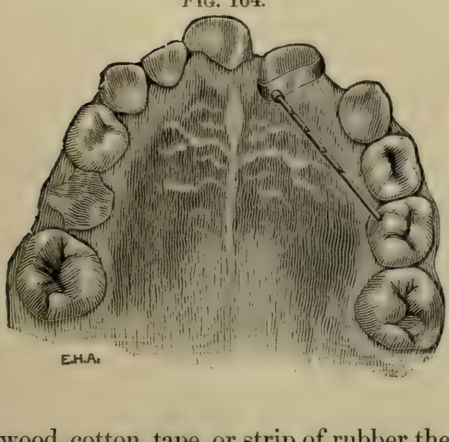
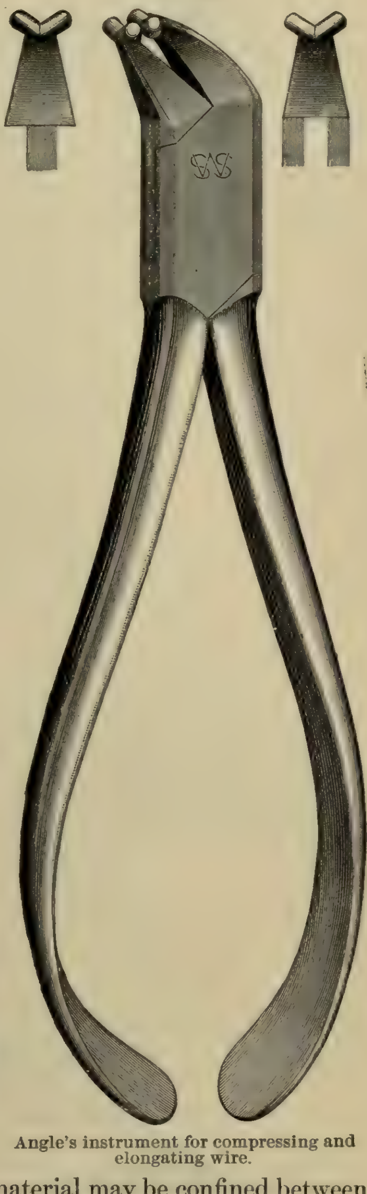


Fig. 165.



Angle's instrument for compressing and elongating wire.

Silk or *linen ligatures* are very useful for moving teeth slowly. If a ligature of floss silk be tied tightly around two teeth not in contact, or

from a tooth to some fixed point on a plate or other appliance, the tooth or teeth will be moved slightly by compression of the peridental membrane, and held thus till absorption takes place.

By frequently renewing such ligatures teeth may be moved some distance. A twisted ligature of silk or linen is more efficacious, because it tightens when wet on account of the swelling of the fibres, and thus continues to act for some time after being put in position. The longer such a twisted ligature is, the more force it will have. Its greatest effect is shown in Fig. 162, where, after being looped around one hook, the two strands are twisted around each other in an opposite direction to the natural twist of the thread, before being tied to another hook or tooth.

Twisted wire ligatures are very efficacious. By looping a copper wire over two pins or hooks the parallel wires may be twisted around each other, once or twice a day, by inserting an excavator or pointed instrument between them, or a square nut may be first put on one wire and the twisting done with a wrench, as devised and used by Dr. C. S. Case (Fig. 163).

Pinched Wire.—A new method of applying force has been introduced by Prof. Angle—the elongation of a straight wire by compressing it in one or more places from day to day by means of round-nose pliers made especially for the purpose (Fig. 165). German-silver wire No. 18 is a suitable size.

Application of Hooks, Tubes, etc.—The chief use of a hook on a band is for rotation by attaching a rubber band or twisted ligature to

FIG. 166.

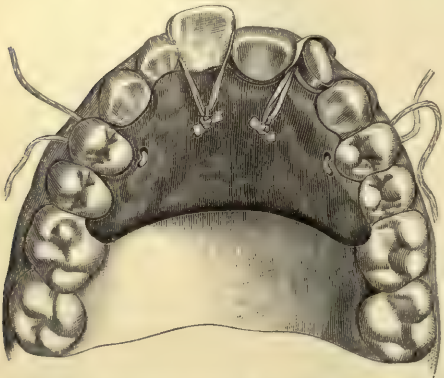
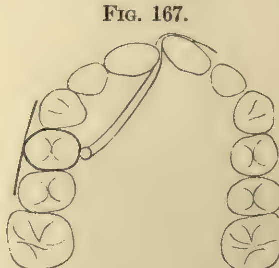


Plate and band for rotating.

FIG. 167.



the hook and extending it to a plate (Fig. 166), or to a hook on another tooth (Fig. 167), or to a labial or lingual bow (Fig. 174).

FIG. 168.

FIG. 169.

In some cases it is necessary to make two hooks on one band, and extend a rubber band from each to some firm point of attachment, as in Fig. 172.

Double rotation may be accomplished by means of two hooks and two bands. Figs. 168 and 169 show double rotation in opposite

Fig. 170.

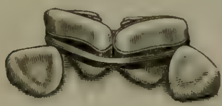


Fig. 171.

directions, and Figs. 170 and 171 in the same direction. Fig. 172 shows the use of hooks for attachment of rubber bands for drawing in a prominent incisor.

It will be noticed that the anchor bands have each a round bar soldered to the buccal surface to increase the anchorage.

Fig. 172.

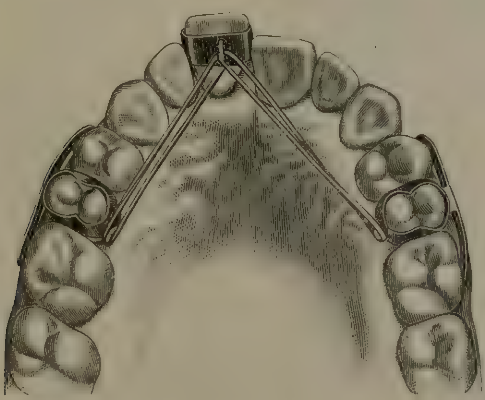
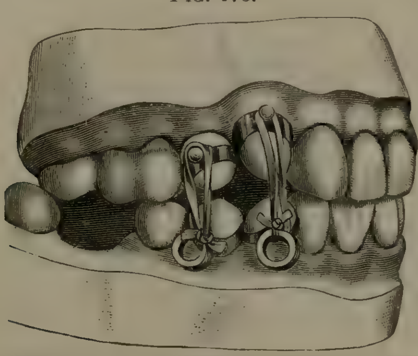


Fig. 173 shows how the author, following the suggestion of Dr. Angle, elongated non-occluding bicuspids and molars and brought them into occlusion by means of rubber bands ligated to the lower

Fig. 173.



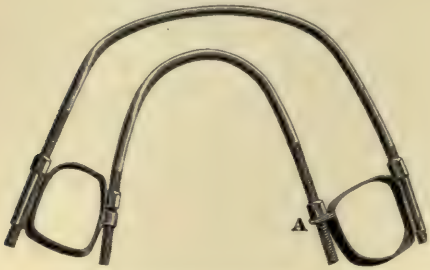
Author's plan of occluding bicuspids and molars.

and extended to hook bands on the upper teeth. One or two extra bands were ligated on each tooth to be used in case of breakage of the first.

SPECIAL APPLIANCES.

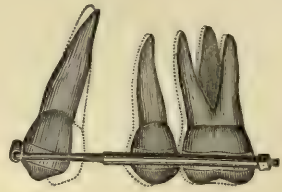
Tubes.—The attachment of a tube to a band serves so many uses as to have almost revolutionized the practice of orthodontia. Figs. 174 and 175 show its use for retaining the end of the labial and lingual bows.

FIG. 174.



Labial and lingual bows.

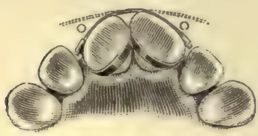
FIG. 175.



Angle's drag-screw.

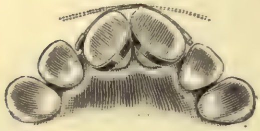
Fig. 176 shows its use with the drag-screw. Fig. 178 shows its use in making up an appliance for spreading the arch.

FIG. 176.



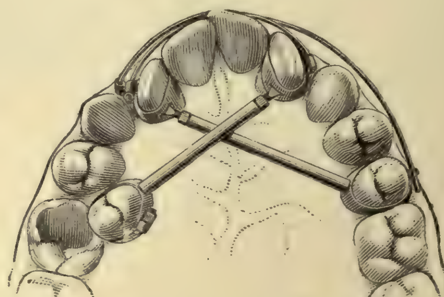
Lugs on angles.

FIG. 177.



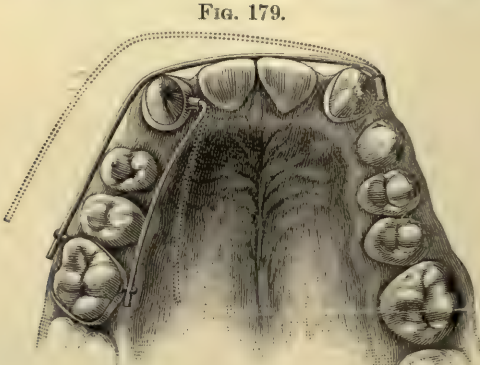
Appliance for double rotation.

FIG. 178.



Tube and piano wire for rotation (Angle).

FIG. 179.



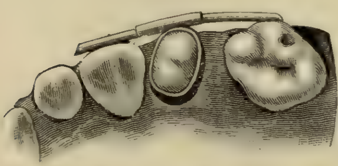
Tube and piano wire for rotation (Angle).

Fig. 177 shows its use for double rotation. In this appliance (Angle's) care must be taken to make the tubes short and solder them

to the labio-buccal line angle of the band. A piece of No. 24 B. & S. G. piano wire inserted in the tubes will rotate the teeth. The author has found it necessary in some cases to solder lugs on the disto-lingual surfaces of the bands to touch upon the lateral incisors and prevent the teeth from being rotated out of the arch.

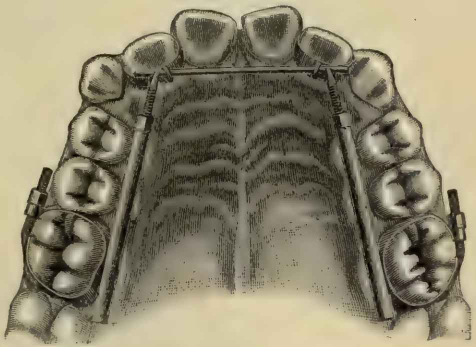
Figs. 179 shows the use of the tube as a socket to insert a lever of piano wire for rotation. Fig. 180 shows the use of the tube for holding a retaining wire for a tooth which has been moved into the line of the arch either labially or lingually. Provision for such retention may be made by attaching such a tube before the tooth is moved (Fig. 182), so that when the tooth is in place a wire can be inserted for retention. Dr. Angle secured this wire by drilling a small hole through one side of the tube and the retaining wire and inserting a small pin.

FIG. 180.



Retainer (Talbot).

FIG. 181.



Providing in advance for retention.

The author has found it a good plan to cement the wire in the tube. A short tube soldered vertically to a band serves as a socket for the end of a jack-screw or spring. A hole drilled or punched in a tube or a slot serves the purpose in many cases.

Another use of tubes or bands is to serve as hooks for attachment of rubber bands in retracting cuspids or bicuspids, as shown in Fig. 182.

FIG. 182.

Author's modification of Guilford's appliance.

When the desired retraction has been accomplished the tubes serve to hold the ends of a labial bow, from which rubber bands may be extended for propulsion or rotation (Fig. 183).

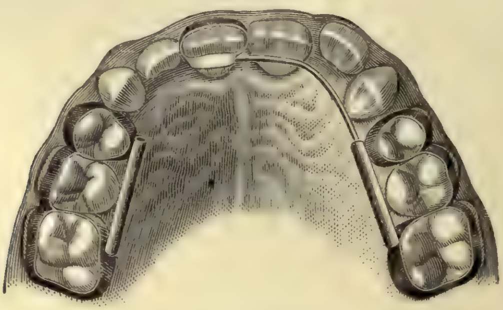
A tube soldered to one or more bands serves as a socket for holding

FIG. 183.

Further use of same tubes for holding bow.

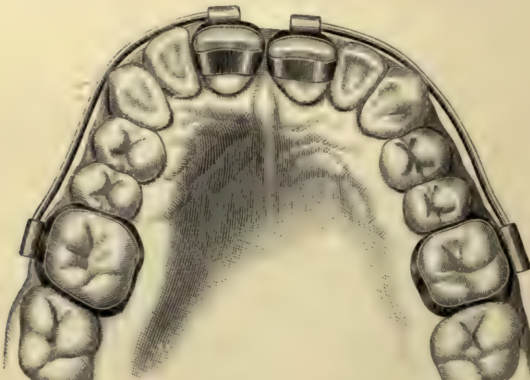
one end of piano wire (Fig. 184), while the other is utilized for moving teeth in different directions (Figs. 184, 185).

FIG. 184.



Tube band and spring appliance (Matteson).

FIG. 185.

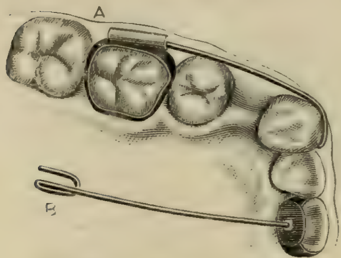


Author's appliance, close bite.

A flat tube for the insertion of the looped end of a spring will hold it more firmly for pressing on the buccal or labial surfaces of teeth (Fig. 186).

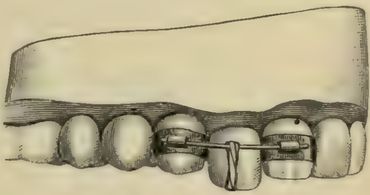
Appliances for Extruded Teeth.—An appliance for pushing an extruded tooth into its socket is readily constructed as follows: Fit

FIG. 186.



Flat tube for piano-wire spring.

FIG. 187.



Appliance for reducing extrusion.

wide bands to the two adjacent teeth, and solder a tube to the lingual and labial surfaces of each band (Fig. 187). When these bands are firmly cemented on the teeth, connect the labial tubes and also the lingual tubes with stiff wires, preferably cemented in the tubes. From the labial wire or bar extend a rubber band or a twisted ligature over the cutting edge or occlusal surface of the extruded tooth, and attach it to the lingual bar. If the extruded tooth is of such shape that the rubber band will not stay in place, cement a swaged cap on the occlusal surface and make a notch in it.

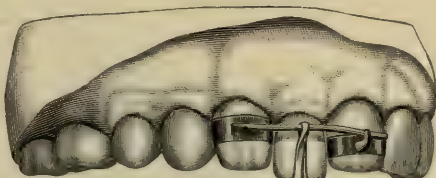
The construction of this appliance is simplified as follows: Instead of tubes, solder on the labial and lingual surfaces of one band stiff wires long enough to reach to the next tooth beyond the one extruded. To make the other band, first double the band material, then about $\frac{1}{16}$ of an inch from the doubled end bend each part at right angles and solder the parts in contact. Finish the band, cutting off the projecting ends about $\frac{1}{16}$ of an inch from the band.

A notch is to be made in the upper side of each projection, and where the band is cemented to the tooth these notches form hooks in which to rest the ends of the wires extending from the other band (Fig. 188, *d*). The rubber band is more easily attached to these bars than to the ones previously described, because it can be slipped over the end of

FIG. 188.

Details of appliance for reducing extrusion.

FIG. 189.

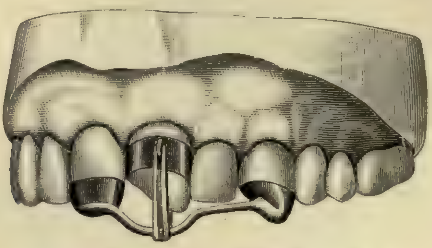


Author's appliance for reducing extrusion.

each wire where it rests in the hook. When the extruded tooth has been pushed up in its socket, it may be retained by substituting a small platinum or silver wire for the rubber band or ligature, but a better plan is to make three bands for the three teeth, solder them together where they are in contact, and cement them to the three teeth.

Appliances for Forcible Eruption.—For this operation an appliance is needed which is just the reverse of the other: for drawing down an

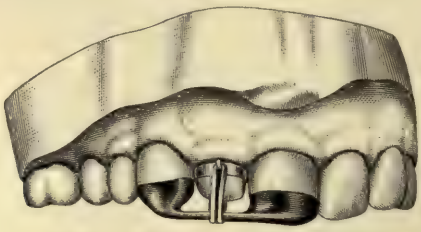
Fig. 190.



Author's appliance for elongating broken tooth.

incisor either partially erupted or broken, swage caps for the contiguous teeth, and connect them by a wire extending from the cutting edge of one to the cutting edge of the other (Figs. 190 and 191).

Fig. 191.



Author's appliance for forcible eruption.

On the tooth to be elongated cement a band made as in Fig. 190, or one to which hooks have been soldered on both labial and lingual surfaces. From the labial hook extend a slender rubber band or twisted ligature over the connecting wire and secure it to the lingual hook. The movement must be slow to avoid rupturing the pulp at the apical foramen. The bar forms a limit beyond which the tooth cannot be drawn. The

Fig. 192.

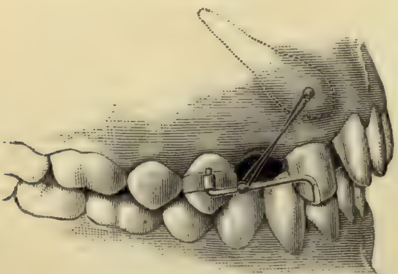
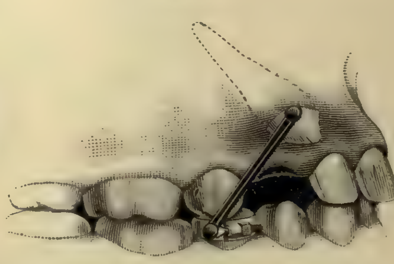


Fig. 193.



Forcible eruption (Angle).

tooth may be retained by substituting a platinum or silver wire for the rubber band, but better by three bands.

Fig. 192 shows Prof. Angle's appliance for elongation or forcible eruption. Its construction is very simple, consisting of a tube soldered to a band on any convenient tooth. From the tube a stiff wire extends across the space, and is hooked over the cutting edge of the next convenient tooth. From this bar a rubber band is extended to a pin anchored in the tardy tooth or to a hook soldered to a cap cemented on the tooth.

Fig. 193 shows a similar appliance in which lower teeth are used for anchorage.

Fig. 194 shows a case treated under the author's directions in the infirmary of the College of Dentistry of the University of California,

Fig. 194.

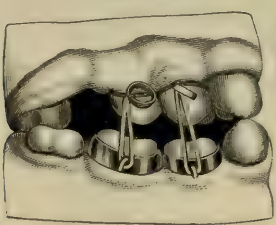
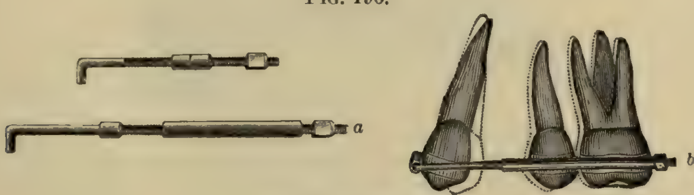


Fig. 195.

by a senior student. The occlusion was brought about in three or four weeks, Fig. 195. During the performance of mastication the patient unhooked the rubber bands, so as not to produce too severe a strain on the alternating teeth.

Application of the Drag-screw.—Angle's drag-screw is one of the most simple and effective appliances. It consists of a stiff wire screw

Fig. 196.



Angle's drag-screw.

cut at one end and bent into a hook at the other. Fig. 196, *a*, shows the appliance; Fig. 196, *b*, shows its use for retracting a cuspid. Double anchorage is secured by soldering a long tube to a molar and a bicuspid band. By this means the two teeth are so firmly yoked together that tipping is prevented, and the teeth, if moved at all, must be dragged bodily through the process.

The attachment to the cuspid varies according to the movement required. If the attachment is made as in Fig. 198, right side, the tooth will be rotated as well as drawn backward. If the hook is attached as in Fig. 197 or Fig. 198, left side, the tooth will be drawn backward without rotating.

Fig. 199 shows the author's use of the drag-screw for reducing a prominent cuspid and at the same time making room, on the principle

Fig. 197.

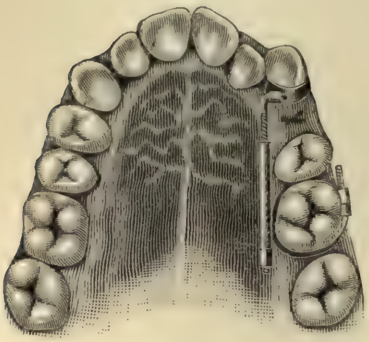
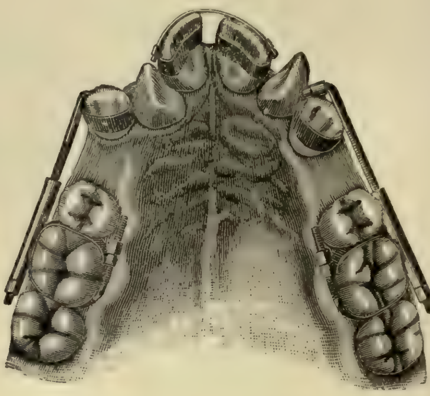


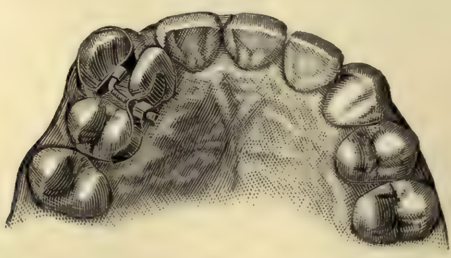
Fig. 198.



of drawing two wedges toward each other. The cuspid forms one wedge and the lingual bar another. The drag-screw, hooked in the cuspid band and drawn through the bar by the nut, forces the two wedges together.

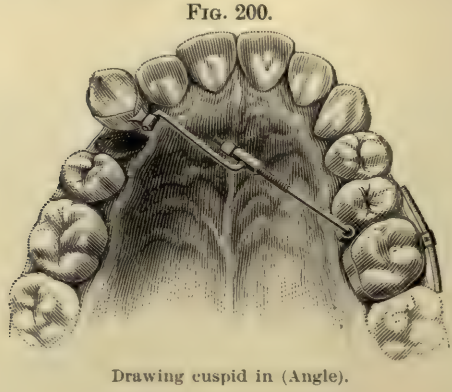
Fig. 200 shows another use of the drag-screw.

Fig. 199.



Author's appliance for making room and drawing cuspid in.

Fig. 200.

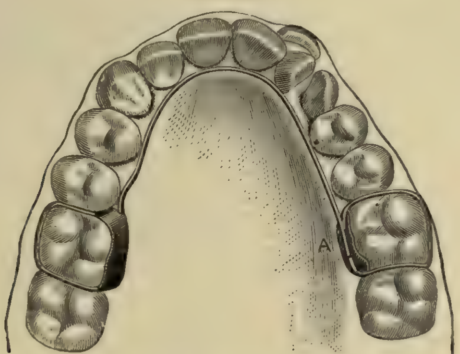


Drawing cuspid in (Angle).

The Jackson Crib.—The crib devised by Dr. V. H. Jackson of New York is essentially a peculiar clasp which clings readily to a molar or bicuspid, and to which springs, screws, etc. may be attached.

Its construction is as follows: First, a piece of German silver plate, No. 30, is fitted to the lingual or buccal surface of a molar or bicuspid. It should be made concave with contouring pliers or by striking a rounded instrument while it rests upon a piece of lead, or against it, so that it will fit snugly against the rounded surface of the tooth, especially at the cervical margin. This is best accomplished by exaggerating the concavity a little, so the piece will touch the tooth only at its edges. (See *A*, Fig. 201.)

FIG. 201.



The Jackson crib and base wire.

The clasp portion is made of piano wire No. 20 B. & S. G., or of hard drawn German silver wire unannealed, slightly larger, by first bending it at right angles (Fig. 202), leaving the width between parallel sides equal to the antero-posterior width of the tooth to be clasped. The part that is to clasp the neck of the tooth is then so bent with clasp-benders that it will be perfectly adapted to the curve of the cervex (Fig. 203). Both arms of the wire are then bent at nearly a right angle at a proper distance to cause them to pass over the grinding surface of the tooth or the points of contact with the adjacent tooth, and again bent in the same manner to extend toward the neck of the tooth on the lingual side (Fig. 204). The ends are next bent toward each other near the gum-line

FIG. 202.

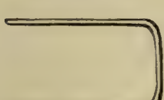


FIG. 203.

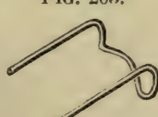
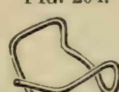


FIG. 204.



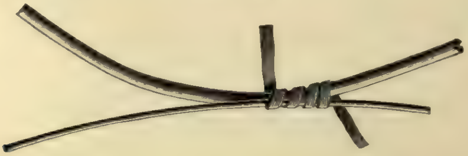
over the piece of metal previously described, as seen at *A* in Fig. 201, and tacked with soft solder. The crib thus made clasps the tooth at the cervico-buccal and cervico-lingual portions, and is prevented from sliding up too far by the wires passing over the occlusal surface.

If a spring is to be attached to the crib, one end should be held in contact with the contoured piece of metal and the ends of the crib wire.

All portions to which it is desired to have the solder adhere, having been previously brightened, should be moistened with dilute chloride of zinc (tinner's acid). A small lump of soft solder laid in contact and touched with a heated soldering copper will flow around and unite all the parts, rounding itself so as scarcely to need further smoothing.

Most of Jackson's appliances consist primarily of a base-wire, No. 12, 13, or 14 B. & S. gauge, connecting cribs on two opposite molars or bicuspids, and bent in a bow corresponding to the lingual surfaces of the teeth (Fig. 201). To this base-wire are soldered springs for moving teeth in different directions according to the requirements of individual cases. By placing all the parts on a cast the end of the base-wire may be readily held in contact with the crib-plate and wire by the thumb protected by a wad of paper while the soft solder is fused with the soldering copper. The end of a spring wire may be held at the same time so as to be united with the rest. A spring may be soldered to any part of the base-wire by binding the two together with fine copper wire and soldering with soft solder. Dr. Jackson has suggested an improvement on this: First, a piece of No. 30 German silver plate is tinned on one side by flowing tin or soft solder over it with a soldering copper. It is then cut into strips about one-thirty-second of an inch in width, to be used in place of the copper wire. To unite two wires one of these strips is wound spirally around them (Fig. 205), with tinned surface next the

FIG. 205.



wires. Upon applying soft solder with the soldering copper it is attracted by the tinned surface and readily flows between and around

FIG. 206.

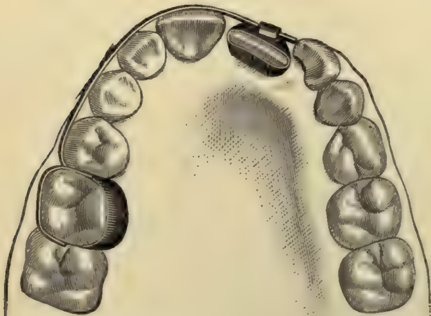
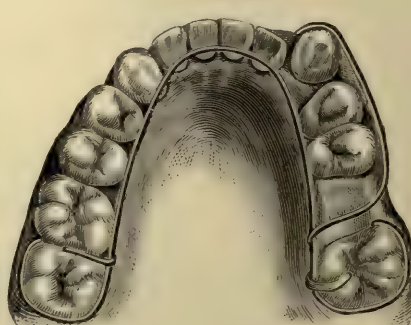


FIG. 207.



both wires and strip, uniting them firmly with a joint less bulky than can be made in any other way.

Figs. 206 and 207 show various applications of the crib and springs.

On account of the deterioration of piano wire through oxidation, Dr. Jackson has almost abandoned its use in favor of hard-drawn German silver wire, using Nos. 12, 13, and 14 for base-wire, Nos. 21 and 22 for cribs, and Nos. 15, 16, 17, and 18 for springs, according to the length and force needed, long springs being made of larger wire than short ones. These cribs and springs may also be made of clasp-gold wire united with hard solder.

Figs. 208 and 209 show another form of crib sometimes used by Dr.

FIG. 208.

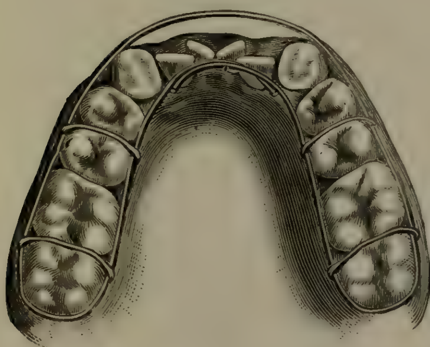
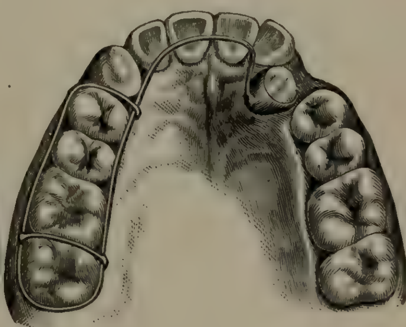


FIG. 209.



Jackson. German silver or piano wire about No. 20 B. & S. gauge is bent so as to enclose a sufficient number of teeth to secure firm anchorage; then one or both ends are extended so as to act as springs for moving teeth in various directions.

The wire may be bent with pliers to fit against the teeth of a plaster cast, though it is better for a novice to use a metal die. At proper intervals cross wires are looped over the buccal and labial wires, so as to extend across the point of contact of teeth and prevent the crib impinging on the gum.

The Coffin Split Plate for Spreading the Arch.[1]—An impression is taken with modelling compound, and allowed to remain in the mouth till quite hard. Special care is taken not to put too much material in the palatine portion of the tray, as it will be forced backward and distort the impression at the necks of the teeth.

When the cast is made trim away slightly the portions representing the gum in the interdental spaces of the molars and bicuspids, both buccally and lingually, so that the plate which covers the crowns of these teeth may project slightly into these spaces and clasp more tightly.

Make a wax base-plate covering the palatine portion of the cast and the entire crowns of bicuspids and molars to the bucco-gingival borders. The palatine portion should be smoothed as for a vulcanite denture, but the wax on occlusal surfaces should be moulded by pressing with the finger, so as to reproduce the cusps and depressions. The finished plate will thus articulate well with the inferior teeth for masticating purposes.

The spring should be made of piano wire No. 20 B. & S. G., which

[1] Introduced at the International Medical Congress, London, Aug., 1881, by Mr. Walter H. Coffin of London.

corresponds to No. 15 of piano-wire gauge, and should be bent in the form and size shown (Fig. 210). The whole spring should be also curved to fit the lingual surface of the plate, and the two arms must be so bent that when they are imbedded in the wax plate near the necks of the bicuspids the rest of the spring will be free from the surface. The ends of the arms should be flattened or bent at right angles for about one-eighth of an inch, so that they may be more firmly held by the vulcanite. If thick tin-foil is burnished on the wax covering the occlusal surfaces of the teeth, and also under the spring, it will line the plaster mould so that the rubber vulcanized against it will need no

Fig. 210.

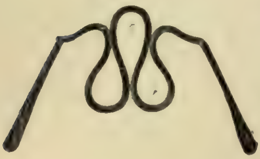
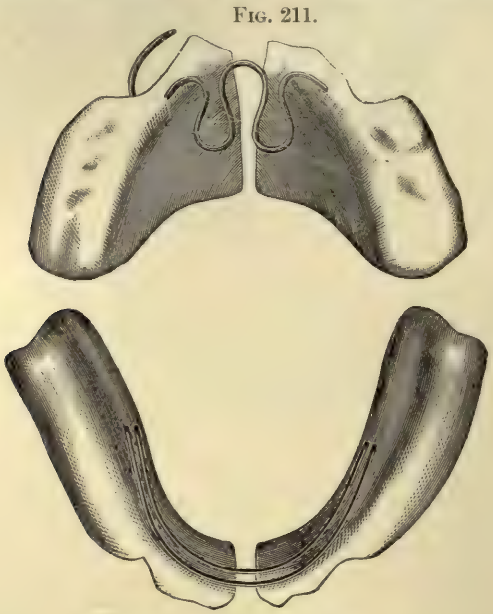


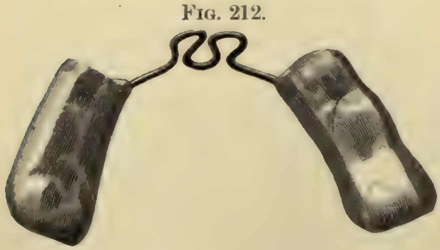
Fig. 211.



Coffin split plates.

further polish. As it is difficult to place the tin under the spring on the wax plate, it is better to wait till the flask is opened, and then burnish it on the lingual portion of the plaster mould. After the plate is vulcanized, smoothed, and polished it should be divided in the median line with a fine saw and the edges slightly rounded to prevent wounding the mucous membrane (Fig. 211). When it is tried in the mouth the lateral portions should slide over the bicuspids and molars so as to grasp them firmly. After the plate has been worn a few days the spring

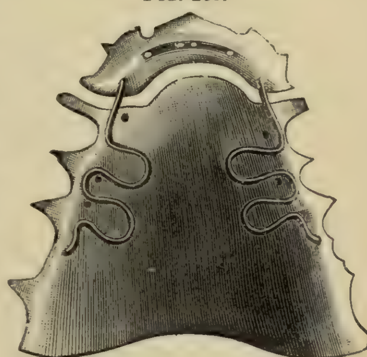
Fig. 212.



should be spread by pulling the halves of the plate slightly apart. When again inserted in the mouth the spring will be compressed so as to exert pressure laterally and spread the arch. For spreading the lower arch the plate should be made as in Fig. 212.

The spring should conform to the lingual surfaces of the incisors, but should not touch them. The Coffin split plate is often made to cover only the palatine surface of the mouth and fit against the necks of the teeth. The cast should be trimmed at the interdental spaces, so that projections of the plate will enter slightly between the teeth to hold it in place.

Fig. 213.



Author's modification of Coffin split plate.

Fig. 213 shows the writer's modification of the Coffin spring plate for moving incisors forward. A Coffin spring is inserted on each side of the plate as near the necks of the teeth as possible, one end of each spring being near the lateral incisors and the other near the molars. It is sawed crossways apart, so that the anterior portion can spring away from the posterior and move incisors forward. A wire nib should project from the anterior portion between the central incisors, or the edge of the plate should rest under projecting bands on the incisors to prevent sliding out of place.

Fixed Appliances for Expansion.—Fig. 214 shows the writer's combination for spreading the arch. It is called a combination because it is made up of bands, tubes, and Angle's jack-screw or Talbot's spring.

Fig. 214.

Author's combination for expansion.

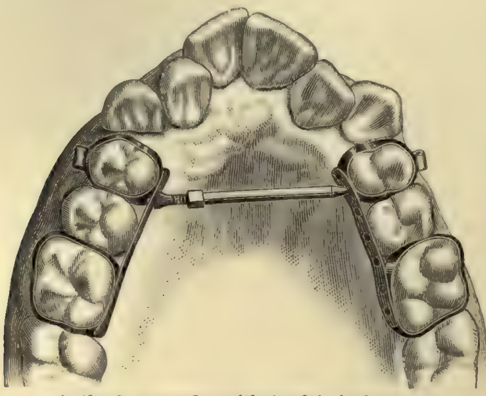
It is easily constructed as follows: Wide bands are made for two teeth on each side, generally the first bicuspid and first molar, but often for the cuspid and second bicuspid. For the cuspid a swaged cap is often better than a band. On the buccal surface of a bicuspid or molar

band a tube is soldered for subsequent use. Each pair of bands is joined to a bar soldered to the lingual surface. This bar is preferably made of clasp gold, but German silver, No. 22 or thicker, may be used, and it should be about one-eighth of an inch wide. Holes are punched in it about one-eighth of an inch apart.

The construction is simplified by placing the bands on a cast of equal parts of plaster and marble dust, sand, or asbestos. A piece of solder is melted on the lingual surface of each band. The cast is tilted on the soldering block, so that the bar when placed in position will be retained by its own weight. When the blowpipe flame is applied the bar will be heated first, and will attract the solder as soon as it is melted, and thus be firmly secured to the bands.

The bar may be long enough to impinge on a tooth anterior or posterior to the banded teeth, so that a greater number will move.

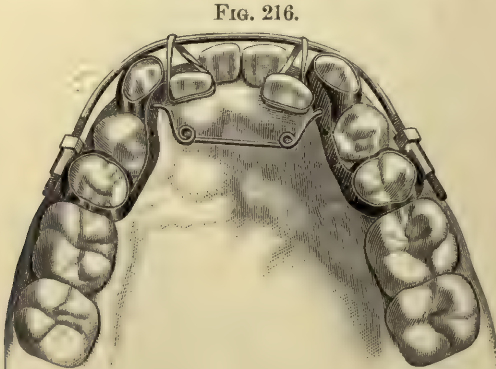
FIG. 215.



Author's expander with Angle's jack-screw.

Either a screw or a spring may be used for force. The Angle jack-screw is the simplest form for intermittent pressure (Fig. 215). The

FIG. 216.



Author's expander for lower arch.

end of the sheath or tube should be pointed and the end of the screw flattened and forked. By placing the pointed end of the sheath or tube

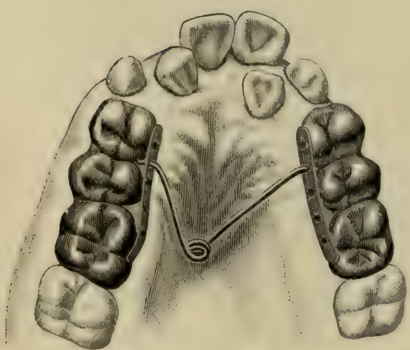
in a hole in the bar on one side, and one prong of the forked end in a hole in the opposite bar, the force may be applied by turning the nut.

On account of the jack-screw being in the way of the tongue the Talbot spring is of less annoyance. The spring should be bent so as to conform to the arch of the palate, but should not touch the mucous membrane (Fig. 217). For the lower arch the Matteson spring is better (Fig. 216).

The ends are bent so as to enter the holes in the bars, and pass in just far enough to remain in position. At subsequent visits of the patient the spring is removed, spread slightly, and replaced.

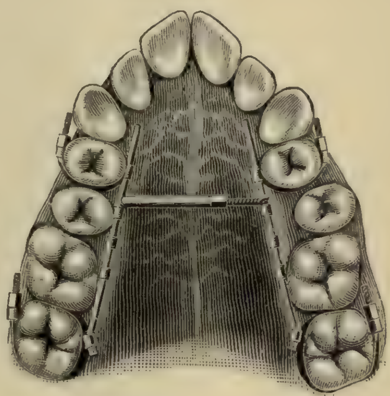
As there are several holes in each bar, the position of the jack-screw or

FIG. 217.



Matteson caps in place of bands in appliance for expanding arch.

FIG. 218.



Angle's appliance for expansion.

spring may be varied according to the needs of the case. Two jack-screws or two springs may be used at once if desired, one at each end of the bar.

When the arch is spread sufficiently, the jack-screw or spring is replaced by a stiff curved wire (Fig. 214, *c*) for retention. The tubes on the buccal surfaces of the bands may then be utilized for the application of a "labial bow" for various uses (Fig. 214, *a*, *b*). The ends of the bow may be bent in bayonet-shape or supplied with thread and nut.

Fig. 218 shows Angle's appliance for expanding the arch. It is made up as follows: Having decided how many teeth are to be moved on each side of the arch, a band is fitted to the anterior and posterior teeth of each phlanyx. These may be either closed or adjustable bands, and each should have a short tube soldered on the lingual surface. These bands should be cemented to the teeth, and the anterior and posterior tubes should be connected by wires extending along the lingual surfaces of the intervening teeth. These wires are best kept in place by cementing them in the tubes. Collars made of short sections of tubing should have been previously soldered on these wires at regular intervals. The force for spreading the arch is gained from a jack-screw. The object of the collars on the side wires is to keep in place the ends of the jack-screw, which may be shifted in position according to where the greatest force is needed. Two jack-screws may be used, one at each end of the appliance.

Bows.—The labial bow extending along the buccal and labial surfaces of the teeth is one of the oldest appliances for attachment of ligatures or rubber bands for moving teeth. The ends of the bow have been secured in various ways—by ligatures, by imbedding in a plate, by soldering to bands or cribs, or by the insertion in tubes soldered to bands or vulcanized into a plate. The bow is made of a flat strip of plate or of round or half-round wire. Round wire is best, as it presents no surface to rest on the teeth, which are therefore more easily kept clean.

Fig. 219 shows a bow of round wire attached to a vulcanite plate. The ends of the bow, bent at right angles, should pass between the teeth

Fig. 219.

Labial bow and plate (Kingsley).

through some convenient space or over the occlusal surface through some space left when the superior and inferior teeth are in contact.

Fig. 220.

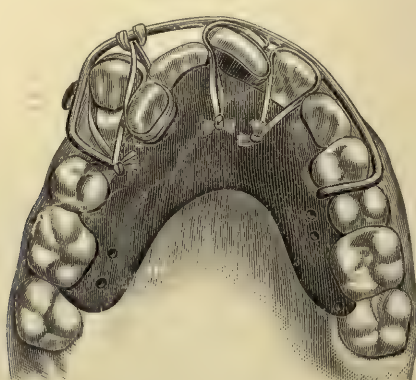


Fig. 220 also shows the manner of attaching rubber bands for moving teeth outward or rotating. In many cases it will be necessary to ligate such a plate to bicuspids or temporary molars.

Fig. 221 shows an almost universal use of such an appliance for moving teeth labially or lingually or for rotating.

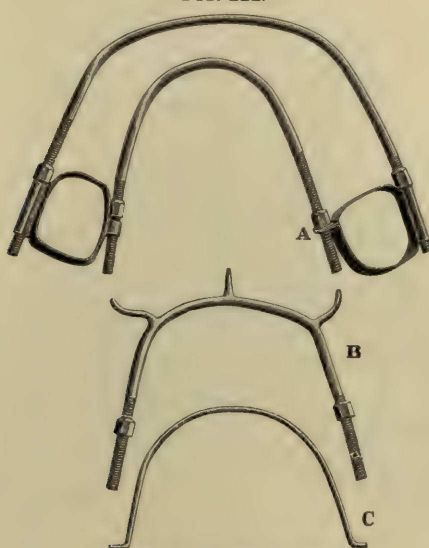
The best method of securing the ends of the labial bow is to insert them in tubes or bands cemented to molars, deciduous or permanent, or

Fig. 221.

Bow for superior protrusion

to bicuspids. In some cases it is best to solder a longer tube to two bands which shall be cemented to two contiguous teeth for better anchor-

Fig. 222.



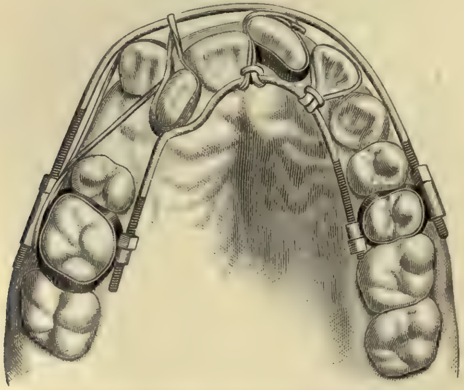
Labial and lingual bow.

age, or two such bands may be soldered together at points of contact and a tube soldered to but one of them.

If the bow is intended merely for attachment of ligatures or rubber bands, the ends may be bent in bayonet shape to prevent their extending too far through the tubes, or, as Prof. Angle suggests, the posterior ends of the tubes may be pinched and closed. The best way, however, is to cut a thread on each end of the bow and apply a nut. If a nut is applied at each end of the tube and tightened, the bow is held very rigidly in position. The bow may be enlarged by loosening the nuts behind the tubes, or made smaller by tightening anterior ones.

Fig. 221 shows how protrusion of anterior teeth may be reduced by

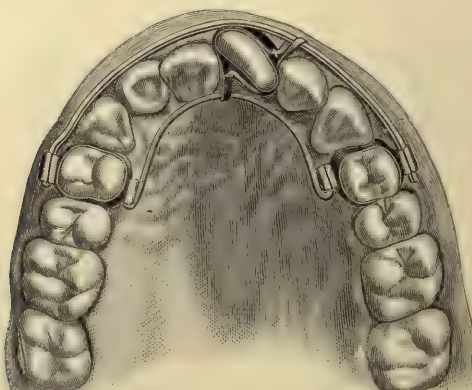
FIG. 223.



Labial and lingual bows for all movements.

tightening nuts behind the tubes. In such a case the anterior portion of the bow should rest in notches or against lugs on bands cemented to central incisors. The simplest method of providing such notches

FIG. 224.



is to join the ends of the band (Fig. 222, *A*) on the labial surface; then, having soldered the parts in contact for about one-sixteenth of an inch, to cut off the surplus and file a notch in the portion left. Fig. 222 also shows another way to make a notch from a tube.

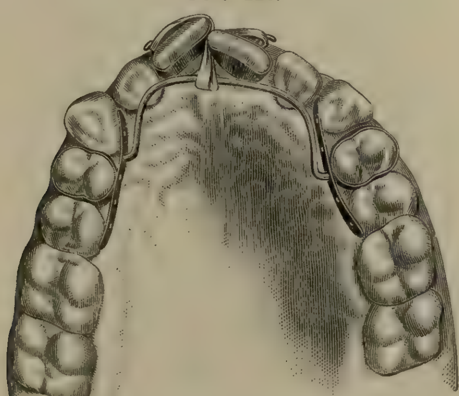
A lingual bow, the ends of which are inserted in tubes on the lingual surfaces of the same bands that anchor the labial bow, is of great advantage in many cases (Fig. 224).

FIG. 225.

Labial bow and hook band for rotation.

This lingual bow may be secured by bending the ends in form of hooks for insertion in the tubes (Fig. 224), or by screw-cutting and ap-

FIG. 226.



Lingual bow and hook band for rotation (author).

plying behind or at both ends of the tubes. The lingual tube may be dispensed with if in making the band the projecting ends are stiffened with solder and a hole punched or drilled through (Fig. 223, *A*).

Fig. 222 shows the two bows used together for the same purposes as the plate and bow in Fig. 220 for all movements of single teeth.

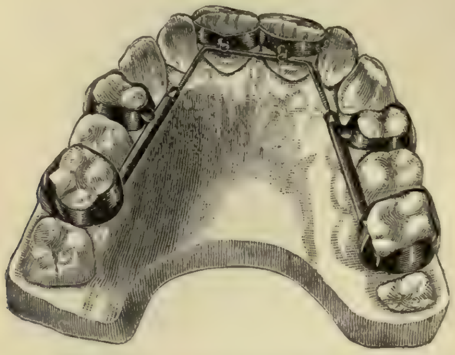
This appliance has the advantage of greater stability and cleanliness.

Figs. 224, 225, and 226 show the bows used for attachment for bands for rotating a tooth.

Fig. 227 shows the use of the lingual bow for moving incisors for-

ward, and Fig. 228 its use in double rotation, while it retains the widened arch after the use of spring or jack-screw.

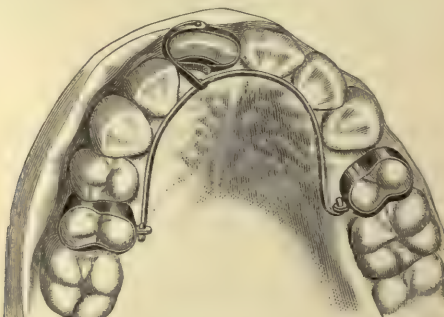
FIG. 227.



Lingual bow for moving incisors forward (Matteson).

Fig. 229 shows one of Dr. Farrar's methods of attaching the labial bow, or, as he calls it, the "long band," to clamp bands. The bow is then used for attachment of ligatures or rubber bands.

FIG. 228.

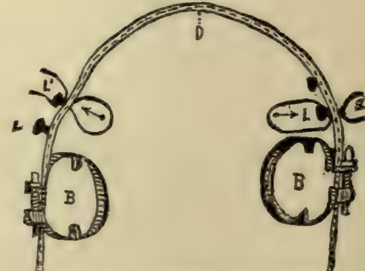


Lingual bow for retention of expanded arch and anchorage in rotation.

FIG. 229.

Labial bow and clamp band (Farrar).

FIG. 230.



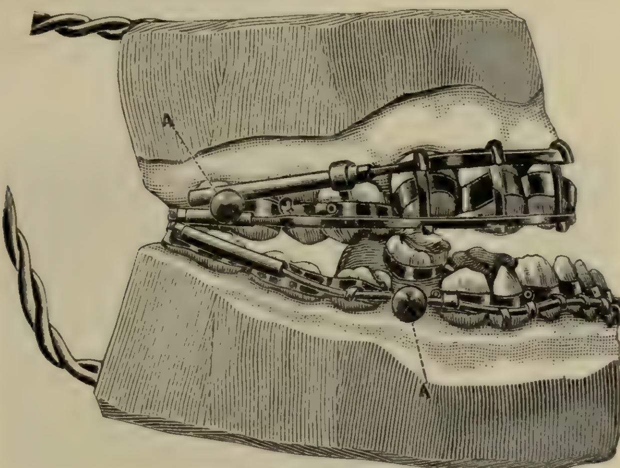
Labial bow and clamp band (Farrar).

Fig. 230 shows another method. Clamp bands are secured by screws on the lingual surfaces of the teeth. On each end of the bow is soldered a smooth bore nut or tube. Through this a screw passes to a nut sol-

dered to the buccal surface of the clamp band. By turning these screws the size of the bow is lessened for reducing superior protrusion.

Fig. 231 shows how Dr. C. S. Case of Chicago used two labial bows at the same time, one for the retraction and the other for propulsion, the

FIG. 231.



Case's appliance for moving roots.

object being to hold back the cutting edges of incisors and cuspids with one bow, while pushing the roots and the enclosing alveolar process forward with the other. The following is Dr. Case's description of the construction : "In constructing the appliance for forcing the roots and adjoining bone of the anterior teeth forward wide German silver banding material for the teeth should be selected that is five- or six-thousandths of an inch in thickness. This should be fitted to the crowns of the anterior teeth near the margins of the gum, perhaps extending beneath the margins on the proximal sides.

"The bars of No. 18, E. S. G. wire, slightly flattened, should be attached to each of the bands in an upright position, and bent so as to lie along the anterior surface of the crowns from the apex (cutting edge) to where the bars join the band ; here they should take a direction somewhat parallel to the gum, but free from the surface to about one-sixteenth (or a quarter) of an inch above its margin, at which point they should be flattened or thinned so as to be more readily bent forward and firmly clasped around a rigid bar (labial bow) which is made to extend from anchorage-tubes attached to the posterior teeth by wide bands.

"This bar (labial bow), which should be very rigid, is drawn without annealing from No. 12 extra hard German silver wire to No. 18 (E. S. G.). The ends are threaded in the No. 4 hole of the Martin screw-plate, and the central portion is slightly flattened in the rollers. Then it should be bent so as to rest when in proper position in the unclasped ends of the upright bars that have been left open to receive it. Before placing it in position the nuts should be screwed on to work at the anterior ends of the tubes.

"The apparatus is completed by a second bar much smaller and

thinner than the first, but proportionately light, which rests in depressions in the upright pieces along the occluding ends of the teeth. The ends of the fulcrum bar are threaded and passed through tubes that are soldered to the anchor bands on each side below the lower bar-tubes with nuts which work posteriorly to the tubes.

"The force expended at the anchorage attachments is largely neutralized by the reciprocating influence of the two forces, and this reciprocation is always equal to the power used on the fulcrum bar in preventing movement of the occluding ends of the crowns."

FIG. 232.

FIG. 233.

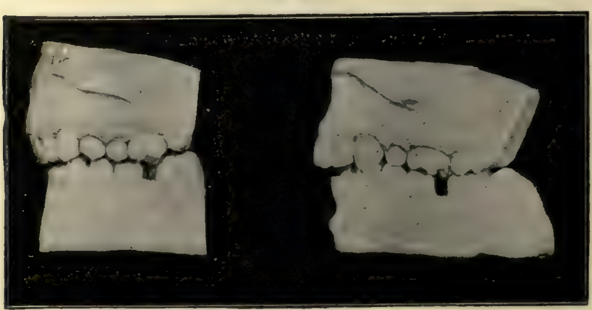
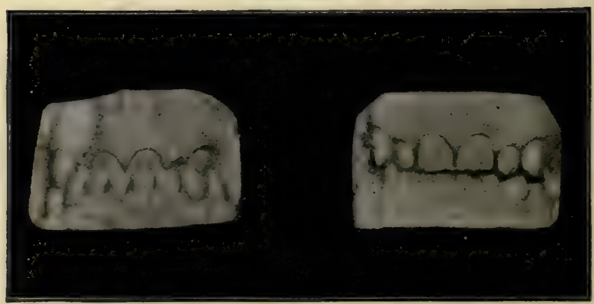


FIG. 234.



Figs. 232, 233, and 234 show half-tone prints of casts of face and teeth, showing change in occlusion of the teeth and also in contour of the face by moving the roots forward.

Fig. 235 shows the details of the appliance.

By reversing the action of these bows, as shown in Fig. 236, the

Fig. 235.

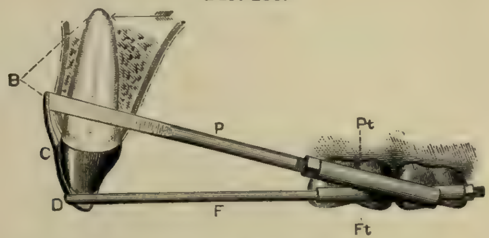
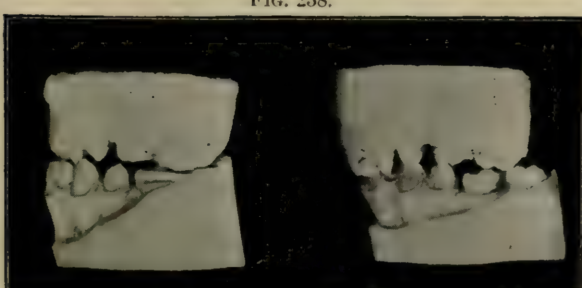


Fig. 236.

Fig. 237.

Fig. 238.



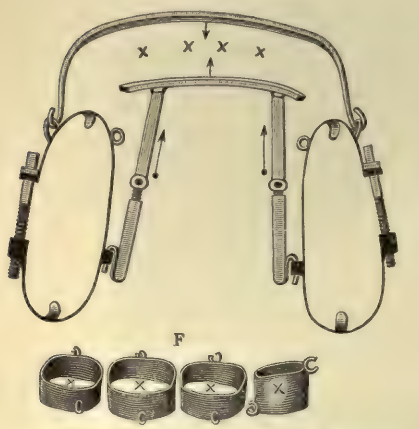
roots of incisors can be forced back. In this case the lower bow is the more rigid, and the anterior portion is placed under hooks in the lower ends of the upright bars. The moving force is in the upper bow, which

rests on the anterior surface of the upper ends of the upright bars. The nuts of the lower bow are placed anterior to the tubes, and those of the upper bow behind.

Figs. 237 and 238 show the result of such an appliance both on the position of the teeth and contour of the face.

Fig. 239 shows Farrar's use of the labial bow for holding the cutting edges of incisors while moving the roots forward by pressing against the lingual cervex with two jack-screws joined to a bar. The bow and bar rest in U-shaped lugs on the incisors. The labial bow, called by Dr. Farrar "the long band," is hooked at each end into clamp bands. Each jack-screw is supplied with a hook which enters a loop in the clamp band.

Fig. 239.



Farrar's appliance for moving roots forward.

Fig. 240.

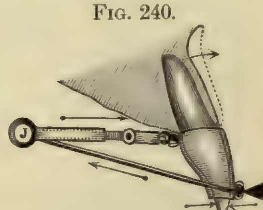
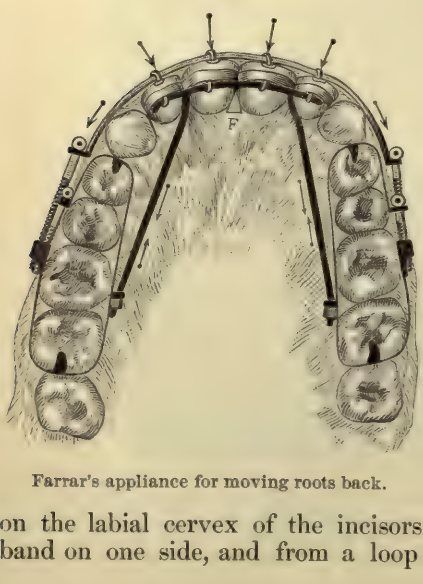


Fig. 240 shows the principle of the action.

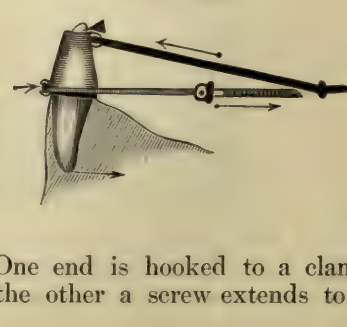
Fig. 241 shows Farrar's use of the labial bow for drawing back the roots of superior incisors while the cutting edges are held in place by a bar and braces on the lingual surface. It is simply the reverse of the other appliance. The bar rests in U-shaped lugs at the cutting edges of the incisors, and is held by braces extending to and resting in loops on the lingual surfaces of the clamp bands. The bow rests in U-shaped lugs on the labial cervex of the incisors. One end is hooked to a clamp band on one side, and from a loop in the other a screw extends to a

Fig. 241.



Farrar's appliance for moving roots back.

Fig. 242.

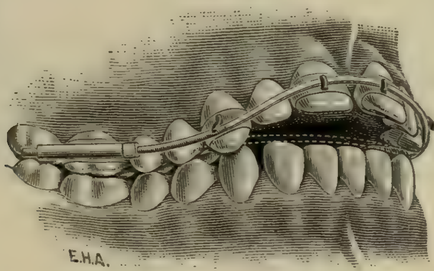


double nut on the buccal side of the other clamp band. By turning this screw force is brought to bear on the roots of the incisors, so as to move them backward, compressing the process behind them.

Fig. 242 shows a sectional view.

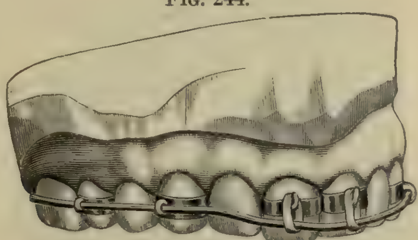
Fig. 243 shows the bow as used by Dr. Angle, and Fig. 244, as used by the writer in 1888 for elongating anterior teeth.

Fig. 243.



On each first molar or second bicuspid is cemented a band with a horizontal buccal tube; on each cuspid is cemented a band with a hook turned downward; and on each incisor that needs elongating is cemented a band with a hook turned up.

Fig. 244.



The ends of an elastic wire bow are inserted in the buccal tubes and passed under the cuspid hooks. The anterior portion is then used for the attachment of slender rubber bands or twisted ligatures extending to the incisor hooks, or is sprung up over the hooks themselves.

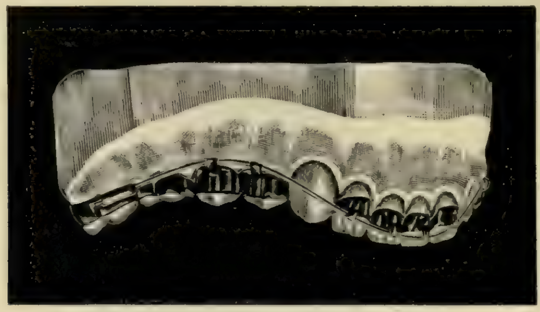
When the teeth have been elongated as much as desirable the same appliance may be still used as a retainer.

Fig. 245 shows the use of the labial bow of the elastic wire for forcibly elongating bicuspids and a molar, and at the same time forcing inferior incisors into their sockets.

A hollow crown is fitted to the last lower molar on each side. This crown should be high enough to open the bite the distance desired. To the buccal surface of each crown is soldered a horizontal tube open at its upper surface. To each tooth which it is desired to raise is cemented a band with a buccal hook turned downward. To each tooth which needs depressing is cemented a band with a hook turned upward. A bow of elastic wire is fitted to the arch, its ends inserted in the buccal tubes of the hollow crowns, its front fitted in the incisor hooks, and its sides sprung

under the bicuspid and molar hooks. When the desired movements have been accomplished the same appliance may be used as a retainer.

FIG. 245.



Case's appliance for raising occlusion.

Occipital Cap.—For cases of superior protrusion in which there is not sufficient anchorage in the mouth a cap and bit may be made as follows: Let a seamstress or some member of the patient's family construct a cap of two pieces of cloth, each shaped like Fig. 246. The seam should be along

FIG. 246.

the dotted line, and the other edges should be hemmed. Dress hooks should be sewed at *a* and *b*. Silesia or some similar cloth is suitable. To make the bit (Fig. 248) first make a cast of the teeth, then mould one thickness of wax over the labial surface of the teeth to be moved, and let the wax extend over the occlusal surfaces and slightly over the lingual. In the anterior surface of the wax, on a line just above the occlusal surfaces, imbed a piece of elastic German silver or nickel-plated wire, No. 12, about 4 inches long, bent in the middle to conform to the curve of the teeth involved and project from the corners of the mouth. The ends should be bent in the form of the hooks, and should project so far that rubber bands extending to the cap will not impinge on the cheeks. Warm

the wire, press it slightly in the wax, and mould wax over it till covered and all inequalities of the wax surface filled up. The case is flasked and a vulcanite piece made like the wax model. The long wire may project from the sides of the flask or may be bent temporarily against the sides of the cast, so as to go in the flask and be straightened out after vulcan-

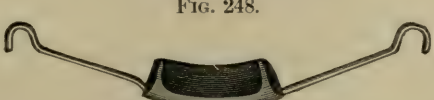
FIG. 247.

Author's form of cap and bit.

izing. After smoothing and polishing try the "bit" in the patient's mouth, and see that the vulcanite does not impinge on the inferior incisors nor on any superior incisors that are not to be moved. Bend the projecting ends so that they will conform to the contour of the cheeks, but will not touch them. Place the cap on the back of the head (Fig. 247). For force use round elastic silk-covered cord, about $\frac{3}{32}$ of an inch in diameter. Tie a knot in one end, and secure it in one of the hooks on the cloth cap; extend it forward over one hook of the bit and back to the other hook on the cap.

It is more convenient to have an assistant fit another elastic cord on the other side of the head at the same time. One strand of the cord may be sufficient; if so, tie a knot in it behind the second hook. Generally

FIG. 248.



more force is needed; if so, extend the cord from the second hook, a second time over the hook of the bit, then back to the first hook on the cloth cap, and secure it by a knot.

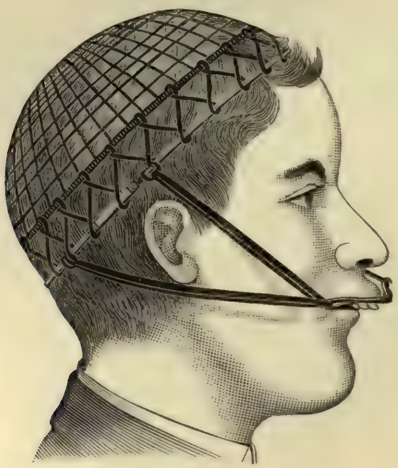
The direction of the force may be varied by the number of strands.

If the teeth need to be pushed up in their sockets, arrange the cord in three upper strands and one lower. If the line of movement should be lower, arrange three lower strands and one upper.

To Dr. Kingsley must be given the credit of first using an occipital appliance for retracting and shortening the incisors in 1866.[1]

Figs. 249 and 250 show Angle's occipital appliance for use in cases of superior protrusion. Adjustable bands (Fig. 250, *D*) with buccal tubes are attached to opposite molars. In these tubes are inserted the ends of

Fig. 249.



a labial bow, to the anterior part of which is soldered a short wire with a rounded end. The bow has also two small collars or hooks soldered near the cuspid region. The anterior portion of the bow rests in notches in the projecting ends of bands on the central incisors. A "yoke" or "bit," shown in Fig. 250, *A*, has a short section of tubing soldered to the middle, so that it can be applied to the projection of the bow when in place. Rubber bands from the hooks on each end extend above and below the ear to the cap on the back of the head.

As the bow is pressed backward it will carry the projecting teeth with it. One advantage of this appliance is that if the teeth are not in a regular arch, they will be forced to conform to the shape of the labial bow. The appliance is to be worn at night and out of school-hours. Rubber bands ligated to the collars on the bow and extended over the tubes on the molar bands serve for retention during the daytime. Bicuspids may be moved outward by rubber bands from the sides of the bow.

The writer has found it best to screw cut the ends of the bow and apply nuts behind the molar tubes.

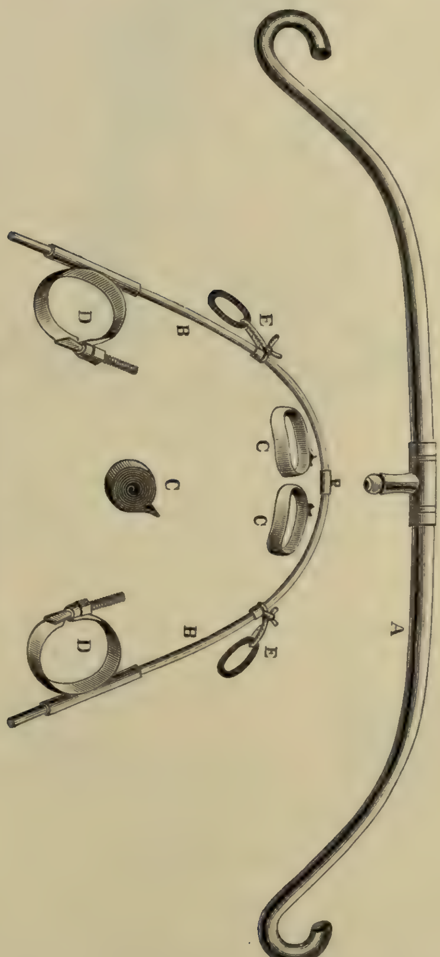
To avoid destroying the stiffness of the German silver bow in hard soldering the spur in front, he finds it best to first solder such a spur to a small piece of tubing with hard solder, then attach the tube to the bow with soft solder. To do this put the tube *T* in position, apply a drop of

[1] Kingsley's *Oral Deformities*, p. 134, Fig. 66.

chloride of zinc, put a small piece of soft solder at the opening of the tube, and hold in a small flame. As the solder melts it will flow between the tube and wire. If the bow is made of clasp gold, it can be hard soldered without injury.

Chin Retractor.—For a chin cap or cup for reducing prognathism or correcting lack of anterior occlusion take an impression of the chin

Fig. 250.



Angle's appliance for retraction.

with very soft modelling compound or plaster. A large impression-tray may be remodelled for the purpose by flattening its palatine portion, or for use with plaster a wax or gutta-percha tray may be moulded to the chin. The operator's hand itself might be used.

If the impression be taken in Teague's impression compound or some similar material, it may be dried and the zinc or Babbitt metal poured in it directly for making a die. Otherwise a model must be made for moulding in sand.

The cup may be made of German silver or of aluminum. The latter is better on account of its lightness. The cup should be swaged and trimmed as shown in Fig. 251. Hooks may be soldered or riveted on

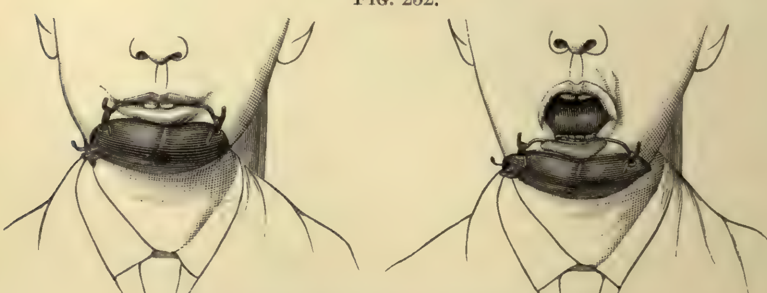
FIG. 251.

Angle's aluminum chin-retractor.

at the upper edge in whatever position will give the most direct strain from the cap, according to the direction required.

Fig. 252 shows an appliance used by the writer for forcing the infe-

FIG. 252.



Author's appliance for depressing inferior incisors.

rior incisors into their sockets. It is useful in cases in which the inferior incisors bite upon the gums back of the superior incisors, or upon the cervico-lingual portions of the teeth themselves, and either cause those teeth to protrude or, when they protrude already, prevent their being moved backward.

Upon a zinc die a cap is swaged to fit over the cutting edges of the inferior teeth. To this is soldered a stiff elastic wire so bent as to extend out of the corners of the mouth and not interfere with the lips. The ends should be bent in the form of hooks. If German silver wire is used for this purpose, it should be united with the cap with soft solder,

as the high heat necessary with silver solder will deprive it of its elasticity. Piano wire nickel-plated may be used. The chin-piece is made as described on page 206, but need not be so large. Rubber bands from the hooks above to hooks or buttons on the chin-piece will force the teeth into their sockets. To prevent the chin-piece sliding forward a piece of tape should extend from it around the neck of the patient.

Retainers.—The simplest retainer for a single tooth is made by soldering a round wire to the labial or lingual surface of a band (Fig. 256, *a*), and cementing the band on the tooth. A round wire is much better than the flat bar used by many, for it touches the tooth only at one point, as shown at Fig. 254, and is easily kept clean, while the bar covers considerable surface, and decay is liable to take place under it during the long time it must be worn.

Fig. 255 shows Guilford's retainer, made by soldering two bands

FIG. 253.

FIG. 254.

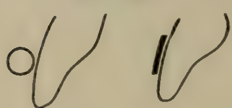


FIG. 255.

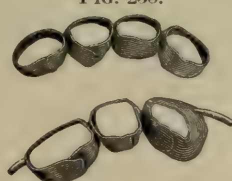
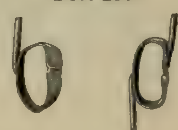


FIG. 256.



together. Several bands may be united for the same purpose. To unite them in proper position place them on the teeth and take an impression in modelling compound. Put the bands in the impression in the positions shown by their imprint. Make a cast of plaster and sand, marble dust, or asbestos. This will show the bands in their proper position, when their contiguous surfaces may be united with solder.

For retaining a rotated tooth solder a wire so that it will project laterally and rest on the labial or lingual surface of the next tooth. It is best in many cases to solder such a wire on both labial and lingual surfaces.

For method of soldering wires, tubes, etc. to bands see page 168.

Figs. 257 and 258 show a retainer, claimed by both Dr. Angle and Dr. Talbot, made by cementing a wire in a tube on a band. Such

FIG. 257.

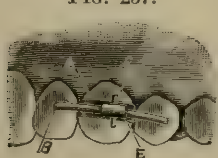
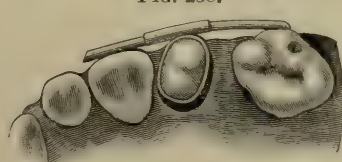


FIG. 258.



a tube may be soldered to a band that serves also some other purpose in moving the tooth, and when the tooth has moved the wire can be inserted for retention.

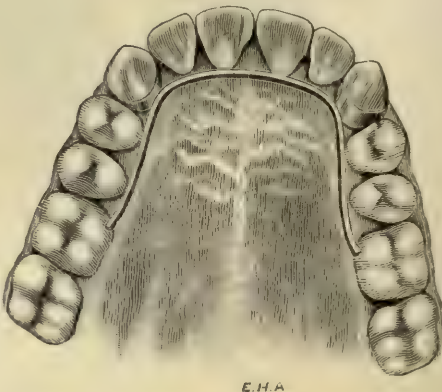
Fig. 259 shows Guilford's band and wire retainer, made by soldering bands to the extremities of a round wire, and used for retaining incisors

that have been moved backward. An impression should be taken with the bands on the teeth, and a cast made for holding the bands while the wire is soldered in the exact position desired.

Fig. 260 shows a similar appliance of Angle's for retaining teeth which have been moved forward. The ends of the bow rest in pits in the first molars or in holes punched in bands cemented on those teeth.

Fig. 259.

Fig. 260.



Either of these retainers may be used in cases in which some incisors have been moved labially and some lingually, by ligating them to the retaining wire with fine platinum or silver suture wire.

Fig. 261 shows Dr. C. S. Case's twisted-wire retainer. A fine wire of copper, platinum, or silver is looped from one hook to another, and by means of an instrument placed between the wires or by using a twisted wrench on a square nut previously placed on one of the wires.

Fig. 261.

Fig. 262.

Fig. 262 shows a crib retainer often used by Dr. Jackson, though Dr. Farrar gives the credit of its suggestion to Dr. W. H. Atkinson.[1] The wire is bent with pliers and clasp-benders to fit the buccal, labial, and lingual surfaces of the teeth accurately. This can be done best on a metal die. Cross wires extend at intervals from one wire to the other to hold them against the teeth, and also to prevent the crib pressing on the gums.

[1] Farrar, vol. i. p. 000, note.

An expanded arch can be retained by an atmospheric-pressure plate, but better by substituting a cross-bar for the jack-screw or a stiff wire for a spring.

Many appliances are of such shape that they can be worn as retainers: jack-screws, drag-screws, bows, and in other cases rubber bands and twisted ligatures, may be substituted by platinum or silver suture wire.

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CHAPTER IV.

MOULDING AND CARVING PORCELAIN TEETH.

By Charles J. Essig, M. D., D. D. S.

The general use of porcelain teeth in dentistry began about 1825. Previous to that date the materials and means employed in the construction of artificial dentures were confined to the various methods of setting human teeth, the teeth of sheep, and forming dentures of hippopotamus tusks, walrus and elephant ivory, etc. The part of the human tooth used by the dentists, except in transplantation, was the crown portion, properly so called. A lost tooth was replaced by one of its own class, attention being paid to matching the natural teeth in such particulars as shape, size, color, and quality.

There were several methods of introduction, as follows: pivoting, by ligatures, with springs, and on bases. The first was deemed by far the best method, but it was only practicable on suitable and healthy roots. Woofendale, writing of this operation in 1783, says: "Another method of supplying the loss of teeth by art is by fixing the crown or enamelled part of the sound human tooth to the root of a tooth of which the enamelled part is wholly decayed or broken. This is done by filing each properly, and uniting them by the assistance of a screw of gold or silver, which may be done so completely that it is sometimes not without difficulty they can be separated, in some instances for several years, provided the orifice in the root of the tooth through which the nerve passes is not much decayed. This operation can only be performed where the teeth have but one root; neither can it be practised when the root of a tooth is out."

Human teeth were also fastened in the mouth by tying them by ligatures of gold or silver wire, silk, cotton thread, etc. Human teeth were costly and scarce. In an advertisement inserted in a Philadelphia paper in 1784, M. Le Mayeur, a dentist, offers two guineas each for sound teeth to be obtained from "persons disposed to sell their front teeth or any of them."

The teeth of cattle were largely used. They were fastened in the mouth by the same means as human teeth. Their color was light and varied but little; the pulp-chambers were very large in proportion to their size, which so weakened the teeth that they were liable to break during mastication, and in other respects they seem to have been unsatisfactory.

Hippopotamus ivory was probably more extensively used than any other of the dental substitutes. When two or more consecutive teeth

were inserted it was almost the only material in use, either as carved in a block into the semblance of the lost natural teeth or as a base on which to secure human or animal teeth.

Ivory of the elephant and walrus and bone were used for the cheaper grades of operations: dentures made of these materials were in every respect unsatisfactory.

Porcelain teeth were not introduced into this country until 1817. The first use of them of which we have knowledge was by A. A. Plantou, a Frenchman, who began the practice of dentistry in Philadelphia about that time. He commenced the manufacture of mineral teeth about 1820, and received for them a certificate of approbation from the Medical Society of Philadelphia.

Charles W. Peale in 1822 and Samuel W. Stockton in 1825 were the next after Plantou to manufacture porcelain teeth: they were soon followed by a host of other experimenters, and by the year 1838 mineral teeth had come into general use.

The form and color of the teeth made about this time very imperfectly represented the natural organs, and the material of which they were made was so poorly adapted to the purpose that exposure to the high temperature necessary to soldering caused their fracture. But about 1838 great improvements were made by Dr. Elias Wildman of Philadelphia. He produced such results in life-like appearance as had not been obtained before, and have truly been said to have remained unexcelled to the present time. To him has been accorded the honor of placing the manufacture of porcelain teeth on a scientific basis.

Materials Used in the Formation of Bodies and Enamels.

These are feldspar, silica, and kaolin or clay. The pigments employed to imitate the various shades of color of the natural enamel, dentine, and gums are titanium oxide, platinum, cobalt, iron, gold, and tin.

The **body** represents the dentine of the natural tooth, and is composed of feldspar, silica (in the form of finely-ground quartz), and kaolin (clay), and the yellow-white or ivory-like color of that portion of a tooth is imparted to it by the addition of finely-ground titanium oxide.

The **frits** are crude colors composed of metallic oxides, such as those of gold, tin, cobalt, etc., ground exceedingly fine, in combination with feldspar and certain fluxes which will hereafter be described. These are burned in a suitable crucible, and then powdered for use in imparting tints to enamels.

Enamels are composed chiefly of feldspar, to which is added sufficient quantities of the different frits to produce as nearly as possible the colors of the natural teeth and gums. Bodies and enamels especially prepared for the manufacture of porcelain teeth should possess, after burning, translucency and natural color, together with strength and heat-conducting qualities to a degree that will admit of soldering without danger of fracture from unequal expansion. Translucency and the power of withstanding high temperature in soldering depend largely upon the feldspar which forms four-fifths of the bulk of the body.

Silica is next in importance as a constituent of the body: its function is to add density and the strength required for masticatory purposes,

and, being highly infusible, to assist in retaining the teeth in shape during the burning process. Without silica the teeth when near the fusing-point would evince a tendency to assume the spherical form, and their lines and characteristic features would be lost.

Kaolin and the clays in general give plasticity to the body, by which the workman is enabled to mould and handle the unburned teeth and blocks without danger of breaking them: it also imparts strength to the porcelain mixture.

Feldspar—generally spoken of as a double silicate of aluminum and potassium—is represented by the formula $Al_2O_3.K_2O.6SiO_2$. The best quality of feldspar is found in the neighborhood of Wilmington, Del. It possesses a distinct cleavage, and when broken splits into plates of more or less magnitude. It is of an indefinite color, between yellow and pink, but when fused in the furnace it becomes transparent and colorless, and if not exposed to a too prolonged or an excessively high temperature it retains its original form without rounding at the corners: this is one of the tests of good feldspar. There are several deposits of this mineral in Eastern Pennsylvania which, though beautiful and transparent in appearance, have been found to be entirely unfit for dental porcelain on account of their opaque-white appearance when fused in the furnace.

Feldspar from different parts of the same quarry has been observed to differ in quality. In selecting spar for the preparation of enamels a number of pieces broken from the most perfect-appearing specimens should be fused in the furnace to determine the quality. The crude pieces from which the samples were taken, if found satisfactory, are then broken into small fragments with a steel hammer until they become of a size to admit of its being ground in a large Wedgwood mortar; at intervals the powder is sifted through a No. 10 bolting-cloth sieve, placed in covered jars, and kept dry for future use.

In the preparation of feldspar for enamels the grinding should not be carried too far, as transparency may be greatly lessened, or even entirely lost, by its being ground too fine. The effect of a complete obliteration of the crystallization of the feldspar by too much grinding may be observed in a test suggested by Dr. William R. Hall in the chapter on "Moulding and Carving Porcelain Teeth," *American System of Dentistry:* It consists in placing on a slide covered with coarse silex a small piece of crude feldspar of the best quality; then taking another piece from the same specimen, grinding it very fine, and fusing the two in the furnace; and when cold the difference in appearance will demonstrate that when ground into a very fine powder loss of transparency is apparent, and that to preserve its beauty feldspar must be ground only to a certain fineness, beyond which opacity is the result.

In preparing feldspar in large quantities for extensive use by the manufacturers of moulded teeth it is customary to calcine the spar by heating to redness, and dropping it into water while hot. This is done to facilitate the reduction of the large masses into small fragments suitable for grinding in the mortar, which in the large factories consists of a tub with a burr-stone or quartz bottom. The pestle, which is generally formed of a piece of the same mineral, is arranged to revolve by machinery. The grinding is done under water. While this plan is less

laborious than dry grinding, it probably never affords as good results, in consequence of the excessive fineness of the powdered spar.

Silica (SiO_2).—This body, sometimes called quartz, occurs in crystalline and amorphous forms: it is colorless, infusible at ordinary temperatures, insoluble in water and in all the acids except hydrofluoric. The amorphous and gelatinous varieties are partially soluble in alkaline carbonates, but quite soluble in caustic alkalies. Silica combines with the bases to form silicates.

The purest natural form of silica is the transparent and colorless variety of quartz known as rock-crystal, which is of frequent occurrence in beautiful six-sided prisms terminated by six-sided pyramids, easily distinguished by their great hardness. Without transparency and crystalline structure silica is met with in the form of chalcedony and carnelian, agate, cat's-eye, onyx, opal, and other precious stones. Sand, of which the whiter varieties are pure silica, appears to have been formed by the disintegration of silicious rocks, and has generally a yellow or brown color, due to the presence of oxide of iron.

Flints, which are generally found in chalk formations, are specimens of the hardest variety of silica, offering greater resistance than quartz to impressions of all kinds. Flint is opaque and of a dull-brown color, which is due to impurities.

A variety of quartz well suited for use in the manufacture of porcelain teeth is found in great abundance in Pennsylvania and other parts of the United States. It occurs in large irregular masses, white in color, and very difficult to powder. It is used for the purpose of giving stability and firmness to porcelains, and its infusibility stiffens and keeps the other materials in shape, so that an object made of porcelain may preserve its moulded form while exposed to the high temperature during the fusing process. For these reasons it is incorporated with feldspar and clay, and is looked upon as the "main prop in tooth-body," in which it is just as essential for the purpose of lessening fusibility, as flux is essential in enamels, which are required to fuse more readily.

Quartz must be ground under water to an impalpable powder. The proper degree of fineness may be ascertained by placing a small portion of the powdered quartz on the end of the tongue: if it is found to be without grittiness when rubbed against the teeth, it may be dried for use.

The preliminary steps in the reduction of this hard mineral to a fine state of division consists in heating to a bright redness as large pieces as the muffle of a furnace will admit, and dropping them into cold water: this causes the quartz to crumble into pieces of the size of a pea, which are further reduced in a Wedgwood mortar by the successive blows of a heavy pestle until fine enough to pass through a No. 10 bolting-cloth sieve, after which it may be brought to the state of an impalpable powder by grinding with water either in an ordinary hard porcelain mortar, or, when it is prepared in very large quantities, by one of the powerful grinding-mills, turned by steam, in use at the large manufactories.

Clay is a hydrated silicate of alumina, and when pure may be represented by the formula $(2Al_2O_3,3SiO_2) + 3H_2O$. It is formed by the long-continued action of air and water upon granite rock, the disintegration of which is probably due to both mechanical and chemical causes. Mechanically, the rock is continually broken down by variations

of temperature and by the congelation of water within its minute pores. Chemically, the action of water containing carbonic acid tends to remove the potash from the feldspar and mica in the form of carbonate of potash, whilst the silicate of alumina and the quartz are separated by the action of the water: the former, being the lighter, is separated from the heavy quartz, and, when again deposited, constitutes clay.

Kaolin is a pure quality of clay from which such impurities as sand and mica have been carefully excluded by washing, which is accomplished by mixing the clay with a large amount of water in a basin-shaped vessel. It is at first thoroughly stirred, and then, after sufficient time has been allowed for the sand to settle, the upper or lighter layer is poured or run off into another vessel. It is then permitted to stand until the kaolin subsides to the bottom of the vessel: the water is siphoned off; the kaolin is then dried, when the mass may be turned out and the bottom scraped free from any sand found adhering to it.

Clay is infusible in an ordinary furnace when heated alone, but readily unites with feldspar, at high temperature, when incorporated with it, and is an element of strength in porcelain compounds.

Kaolin should be thoroughly mixed with the other ingredients of the body while in the dry state, and complete admixtures may be attained by passing the dry body through a No. 9 bolting-cloth sieve.

German clay is imported from Europe, and is used to manufacture various articles which require an infusible silicate of aluminum.

Formulas for Body.

The different materials entering into the composition of bodies should be kept in a dry state in labelled jars, and the weighing of each before mixing should be done with precision. The following formulas of well-tested standard bodies for moulded block teeth are given by Dr. Wm. R. Hall:[1]

Bodies for Moulded Block Teeth.

I.		II.	
Kaolin	1 oz.	German clay	½ oz.
Silica	3 "	Silica	3 "
Feldspar	18 "	Feldspar	18 "
Titanium oxide	65 gr.	Titanium oxide	65 gr.
Starch, 10 gr. to each oz.		Starch, 10 gr. to each oz.	

It was formerly the custom of makers of moulded teeth to at first partially burn or biscuit-bake the teeth or blocks. The addition of starch to the body does away with the necessity of the "first burning," as it gives the teeth sufficient firmness to allow of their being safely handled during the process of trimming, which must be done before the final burning. The titanium oxide and the starch are placed in a mortar and ground, at first without water; kaolin and silica are then added, ground together, and sifted through a No. 9 bolting-cloth sieve: the feldspar is then added, and after sieving a second time the mixture is ready for use, and should be kept in a covered glass jar. As it is often desirable to have in stock a small variety of bodies of different shades, it will be found of great convenience to have attached to each jar a test

[1] *American System of Dentistry*, p. 962.

sample of the body, which has been burned in the furnace, so that color and texture may be ascertained without loss of time.

In preparing bodies and enamels for use in moulds they are mixed with water, and then dried to the consistence of dough, when they are placed in the moulds with small spatulas. The enamels being laid in the face side and the body in the pin side of the moulds, these two halves of the mould are then adjusted to each other, placed in a strong press until in complete contact, secured by a strong clamp, and exposed to a heat sufficient to bake the starch, which so hardens the teeth or blocks that they will withstand a very considerable amount of force without danger of breaking. During the burning of the teeth the starch burns out without injury to either the body or enamels.

In bodies used for carved blocks no starch need be used. The work being done entirely by hand with small knives, it is essential that the material should be plastic enough to cut with facility, while it possesses sufficient toughness to permit of careful handling. These conditions are obtained by simply mixing the body with water, the kaolin present furnishing the desired plasticity.

Bodies for Carved Blocks.

Dr. William R. Hall's formulas:

No. 1.		No. 2.	
Kaolin	1 oz.	German clay	½ oz.
Silica	3½ "	Silica	3½ "
Feldspar	14 "	Feldspar	14 "
Titanium oxide	40 gr.	Titanium oxide	40 "

Formulas of Professor Wildman:

No. 1.		No. 2.	
Feldspar	4 oz.	Feldspar (Delaware)	3 oz.
Silica	320 gr.	Feldspar (Wissahickon)	1 "
Kaolin (Massey's)	120 "	Kaolin (Hoopes')	40 gr.
Titanium oxide	4 to 8 "	Kaolin (Massey's)	80 "
		Silica	360 "
		Titanium	4 to 8 "

These bodies are of medium color: they may be made darker or lighter by varying the quantity of titanium oxide. Iron or steel spatulas should not be used in mixing bodies: bone or ivory mixers may be used without fear of contaminating the material.

Colors used in the Manufacture of Porcelain Teeth.

The colors used in imitating the tints of the natural enamel, dentine, and gums are produced by thoroughly incorporating titanium oxide and preparations of gold, tin, platinum, iron, and cobalt with the mineral substances of which porcelain bodies and enamels are composed.

The texture and coloring of porcelain teeth have reached a high state of perfection in the United States and England. The making and application of bodies and enamels, while requiring much skill and experience, are undoubtedly greatly in advance of forms and sizes. In the direction of colors and texture we have probably all that could be desired. And the fact that artificial teeth have not reached a sufficiently

high standard of artistic perfection to enable them to imitate the natural organs closely enough to defy detection, is certainly not due to any deficiency in the materials of which they are made, but to other causes which will be considered hereafter.

Color frits are made by grinding the metal or its oxide with feldspar and a fine quality of glass, which serves as a flux to lower the fusibility of the enamel. The levigation is continued until a very fine state of division is reached, after which they are biscuit-burned in the muffle of a furnace, or they may be securely packed in a white-clay crucible, provided with a perfectly secure top, and burned in any ordinary stove or furnace in which a high enough temperature can be obtained. When cool the frit is removed and pulverized in a Wedgwood mortar, which has first been thoroughly scoured out by grinding with coarse silica to effectually remove traces of any coloring pigment previously prepared in the same mortar.

In grinding prepared platinum or gold-foil the feldspar and flux are added by small portions at a time until the greatest degree of fineness is attained. The shade of the enamel will depend largely upon the state of minute division of the metal or oxide. As an example it may be stated that distinctly different shades may be made from portions of the same mixture by reducing one lot to extreme fineness and leaving the other comparatively coarse.

Blue Frits.

Wm. R. Hall's formulas :

Platinum Frit, Blue.

Platinum (dissolved in aqua regia)	1 dwt.
Feldspar	1 oz.
Plate glass	20 gr.

Platinum Frit, Gray.

Platinum frit	30 gr.
Titanium oxide	10 "
Gold frit	100 "

Cobalt Frit, Azure Blue.

Smalt (cobalt)	60 gr.
Titanium oxide	6 "
Gold frit	60 "
Feldspar	1 oz.

Iron Frit, Gray.

Iron scale	4 gr.
Titanium oxide	1 "
Gold frit	60 "
Feldspar	1 oz.

Gold Frit, Reddish-brown.

Pure gold-foil	12 gr.
Plate glass	20 "
Feldspar	1 oz.

Dr. Wm. R. Hall's directions for preparing the platinum and gold frits are as follows: "The metal for the platinum frit is dissolved in boiling nitro-muriatic acid, care being taken not to use more acid than is just sufficient to make a saturated solution. When cold the spar and glass are added and mixed with a glass rod, and placed in a clay crucible previously washed inside with powdered quartz mixed with water. A cover must be closely fitted to the inner edges of the crucible, the joint being carefully closed or luted with clay and quartz, and burned as has been described.

"The metal of the gold frit is dissolved in cold nitro-hydrochloric

acid: with this exception it is treated in the same way as in the directions for the platinum frit."

Professor Wildman, who called the gold frit "silicate of gold," directed that "coarse feldspar 120 gr., gold-foil 10 gr., flux 8 gr. be placed in a mortar and ground until the gold is entirely cut up: it is then made into a ball, placed on a slide, and fused in the muffle; then made fine, ready for use." His "gold mixture" was made by dissolving 8 grains of gold-foil in aqua regia, to which were added and well stirred 300 grains of very finely pulverized feldspar. When nearly dry the mixture was formed into a ball and fused on a slide in the muffle of the furnace, after which it was pulverized and kept dry for use.

Professor Wildman's Formulas for Point and Base Enamels.

No. 1, for Points (gray).

Feldspar	1 oz.
Silicate of gold	6 gr.
Prep. sponge platinum	4 "
Flux	20 "

No. 2, Neck or Base (yellow).

Feldspar	1 oz.
Titanium oxide	8 gr.
Prep. sponge platinum	4 "
Flux	24 "

No. 3, Yellow.

Feldspar	1 oz.
Titanium oxide	8 gr.
Prep. sponge platinum	4 "
Gold mixture	25 "
Flux	24 "

No. 4, Gray.

Feldspar	1 oz.
Titanium oxide	1½ gr.
Prep. sponge platinum	4 "
Light cobalt ashes	4 "
Flux	24 "

No. 5, Blue.

Feldspar	1 oz.
Sponge platinum	3 gr.
Light cobalt ashes	2–3 "
Flux	24 "

The enamels of Professor Wildman were more fusible than those of William R. Hall, and were probably not as well adapted for moulding and general manufacturing purposes as were those of the latter, though in translucency, texture, and color they were unsurpassed.

The making of bodies and enamels and their application require both skill and experience. There should also be a correct relation of fusing-points between bodies and enamels. As the fusibility of the bodies of Hall and Wildman probably differ, it would not do to use the enamels of one with the bodies of the other.

In preparing coloring frits it should be borne in mind that a too high or long-continued heat may reduce the oxides to a metallic state, and thus ruin them for use as coloring pigments. The burning should either be done in the muffle of the furnace or in a white-clay crucible provided with a top securely luted in and made perfectly tight with a mixture of silica and kaolin, for the purpose of protecting the frit from the action of the fuel-gases. The burning should be done at a temperature sufficiently high to glaze the frit, and the crucible need not be placed in the furnace until that point has been nearly attained, otherwise it might deteriorate in its color-giving qualities by too long exposure to heat.

Directions for Making Professor Wildman's Enamels.

Prof. Wildman seemed to have preferred the dry method of making colors. The "prepared platinum" which he used in point enamels was made by grinding 1 part of sponge platinum with 15 parts of feldspar. In compounding No. 1 point enamel he directed that the "prepared platinum" be ground alone until extreme fineness be reached, after which the silicate of gold and flux are to be added, and thoroughly ground until reduced to the fineness of the platinum. There is no danger of getting these coloring pigments too fine; but with the feldspar, which is next to be added, the case is different: it is added a little at a time until thoroughly incorporated with the platinum and gold mixtures and the flux; but the spar must not be ground too fine, or its "life and beauty will be lost and we shall have a glassy enamel." The manner in which Dr. Wildman ascertained the correct degree of fineness of the enamel after the spar was added was "to take a little of the enamel out of the mortar, mix it with water, and apply to a piece of biscuited body; when nearly dry, cut a few indentations in it, and pass the finger lightly over it; if it rubs perfectly smooth, it is fine enough for use."

No. 2 base or yellow enamel was prepared by first grinding the titanium and platinum together, the shade of this enamel depending very much upon a state of minute division of these colors. If the platinum is brought to a greater state of fineness than the titanium, the latter will be masked, and the resulting color will be of a greenish tint; but when the degree of fineness of the two pigments is equal, the yellow imparted by the titanium is merely softened or toned by the platinum, and a color is produced which admirably imitates the shade of the base of a healthy natural tooth. By grinding either of these colors separately to a state of extreme fineness, and then adding the other, which has not been brought to so high a state of minute division, the finer color will be found to predominate, shaded only by the coarser one. The flux is next added, and, as coarse particles of this material are liable to produce small air-bubbles in the surface of the enamel, it must also be ground very fine. The spar is now added a little at a time, as in No. 1 enamel.

In making No. 3 enamels the procedure is precisely the same as in Nos. 1 and 2, with the exception of the addition of the gold mixture, which yields a brownish tint, the depth of shade being governed by the quantity used. When it is desired to but slightly shade the yellow a smaller amount of the gold mixture may be added.

Nos. 4 and 5, gray and blue enamels, are prepared as directed in making the preceding numbers, with the addition of the "light cobalt-ashes," 2 grains of which produces a light-blue shade, and 3 grains when the blue is required to predominate.

Dr. William R. Hall's Formulas for Enamels.

It will be observed that the enamels of Dr. Hall have no flux as an ingredient other than that which is contained in the different frits. In this respect they differ materially from the formulas of Prof. Wildman. On the ground that fluxes give a glassy surface to the finished teeth

and decrease the beauty of good spar, Dr. Hall asserts that none should be used in enamels.

Platinum-gray, No. 1.		*Platinum-blue, No. 1.*		*Iron-gray, No. 4.*	
Plat.-gray frit	1 gr.	Plat.-blue frit	1 gr.	Iron-gray frit	4 gr.
Feldspar	1 oz.	Feldspar	1 oz.	Feldspar	1 oz.
Starch	15 gr.	Starch	15 gr.	Starch	15 gr.

No. 2.		*No. 3.*		*No. 6.*	
Plat.-gray frit	2 gr.	Plat.-blue frit	3 gr.	Iron-gray frit	6 gr.
Feldspar	1 oz.	Feldspar	1 oz.	Feldspar	1 oz.
Starch	15 gr.	Starch	15 gr.	Starch	15 gr.

Platinum-gray, No. 4.		*Platinum-blue, No. 5.*		*Iron-gray, No. 8.*	
Plat.-gray frit	4 gr.	Plat.-blue frit	5 gr.	Iron-gray frit	8 gr.
Feldspar	1 oz.	Feldspar	1 oz.	Feldspar	1 oz.
Starch	15 gr.	Starch	15 gr.	Starch	15 gr.

Gold-yellow, No. 1.		*Gold-yellow, No. 2.*		*Gold-yellow, No. 3.*	
Titanium, pure	1 gr.	Titanium, pure	2 gr.	Titanium, pure	3 gr.
Gold frit	2 "	Gold frit	4 "	Gold frit	6 "
Starch	15 "	Starch	15 "	Starch	15 "
Feldspar	1 oz.	Feldspar	1 oz.	Feldspar	1 oz.

Brown-yellow, No. 1.		*Brown-yellow, No. 2.*	
Titanium, pure	1 gr.	Titanium, pure	2 gr.
Platinum frit	1 "	Platinum frit	2 "
Gum frit	4 "	Gum frit	8 "
Feldspar	1 oz.	Feldspar	1 oz.
Starch	15 gr.	Starch	15 gr.

The tint of enamels is more or less influenced by the quality of the feldspar, some varieties imparting a blue and some a white or slightly yellow tint. A feldspar from Marcus Hook in Delaware county, Pennsylvania, has been found to afford a beautiful white enamel, which answers admirably for teeth suitable for persons of the lymphatic temperament—a type which requires little or no color.

Cobalt, which has been mentioned as one of the occasional coloring ingredients in enamels, is what is known in commerce as "smalt." It is sometimes used in producing the brighter shades of blue. It is not, however, a permanent color, and it requires to be associated with some other color, such as platinum, to prevent it from being lost during the burning of the teeth.

Dr. Hall objects to the use of *sponge platinum* in the formation of platinum frit, on the ground that it is more expensive and requires much heavy grinding to cut it sufficiently fine to make good frit, his preference being for the method in which the metal is dissolved in nitro-hydrochloric acid, as described on page 216.

Sponge platinum is made by dissolving pure platinum filings or scraps in six times their weight of nitro-hydrochloric acid composed of 1 part of nitric to 3 parts of hydrochloric. The platinum and mixed acid should be placed in a clean Florence flask and heat gently applied by means of a sand-bath, for the purpose of facilitating the action of the

acid on the metal. The heat should not be too great, otherwise the effervescence will be so violent that a portion of the mixture may be ejected from the flask. Should effervescence cease entirely before all the metal is dissolved, the fluid must be decanted and more acid added until the last particle of the platinum disappears. The solution is then poured into an evaporating dish and evaporated on the sand-bath until the mass is nearly dry and the resulting salt assumes the crystalline form. At this part of the operation care must be taken that the temperature of the sand-bath is kept below 450° F.; above that point decomposition of the platinic chloride takes place, when a portion of the chlorine is driven off, causing a precipitate of platinous chloride, which is of a greenish-gray color and insoluble in water. If, however, no such accident occurs, the platinic chloride will be of a reddish-brown color, very deliquescent and freely soluble in water. The crystallized salt is dissolved in pure distilled water, and allowed to stand until it becomes perfectly clear, when it is to be filtered, after which a cold saturated solution of ammonium chloride (sal ammoniac) is gradually added to the platinic chloride until all precipitation ceases. When the precipitate has entirely settled it is collected by pouring off the liquid, thoroughly washing the spongy metal, drying, and placing away for future use in small glass jars.

Iron scale when combined with spar makes an exceedingly natural blue-gray color, suitable, when toned by combination with other frits, as designated in the formula on p. 219, for the cutting edges of the teeth of young persons.

The Application of Enamels.

In the formulas of Professor Wildman, when the enamels are to be used on body No. 1, 30 grains of flux must be added to the former, instead of 24, as given in the formula. Enamel No. 1 is intended for shading the points or cutting edges of the teeth. It is to be applied to the face of the tooth, much thicker at the point than at the base, and it must extend somewhat beyond the body in order to imitate the translucency of that portion of the teeth of young adults, but if the enamel has been ground too fine, it will be impossible to obtain this appearance.

No. 2 enamel is for shading the base of the tooth. It should be applied first and laid on thick at the base or neck, becoming thinner and terminating near the cutting edge. No. 1, being laid on after No. 2, must partially cover it, so that they will not terminate too abruptly and thus present a line of demarkation between the two colors.

Enamel No. 3 is also used for shading the base or neck: it has a browner hue than No. 2, and in many cases is preferable to it, on account of the yellow being softened and toned by the gold mixture.

Enamel No. 4, used on a yellow body, is a good color with which to imitate the teeth of elderly people.

Enamel No. 5, when applied on a light body as a point enamel, affords a clear bluish appearance which is very desirable in some cases. A very good color may be produced in imitation of the teeth of elderly persons by first applying on a yellow body a thin coating of enamel No. 3 over the whole tooth, and then commencing as usual by applying the point enamel, and adding No. 3 base enamel to the neck of the tooth. The

underlying color, showing through, gives the whole tooth a grayish shade. Enamels are to be ground dry and kept so, and are to be mixed with clean water only at the moment of their application.

From the few colors given by Professor Wildman an almost endless variety of tints may be obtained by alterations in the shades of the bodies, by making the coloring pigments of the enamels of different degrees of fineness, and by laying on the enamels in different degrees of thickness.

In the preparation of enamels care must be taken to select only good feldspar, and, above all, to avoid grinding it too fine, the latter being the cause of the loss of translucency, and indeed of all the desirable qualities of an enamel.

Gum Frit (Purple of Cassius).

The dry method[1] is the one now employed by manufacturers of porcelain teeth in the preparation of purple of Cassius, the coloring pigment in gum enamel. Pure silver 240 gr., pure gold 24 gr., and pure tin $17\frac{1}{2}$ gr. are placed in a crucible, with sufficient borax to cover the mass, and melted. In order to ensure a thorough mixture of the different metals the melted mass should be poured from a height into a vessel of cold water, and this process of granulation should be repeated at least three times; but at every melting the alloy should be well covered with borax to prevent loss of the tin by oxidation. The vessel into which the molten mass is poured should not be a metallic one.

The component parts of the alloy having now been thoroughly incorporated, the next step is to collect the granulated mass and separate from it any adherent particles of glass or borax. The metal is then put into a glass or porcelain evaporating-dish (the Berlin porcelain is the best), and sufficient chemically pure nitric acid is added to cover the metal. The dish is now placed over a sand-bath, and gentle heat applied and continued until chemical action ceases. If at this point it is found that all the metallic particles are dissolved, the dish may be removed from the bath. Should any solid particles be found in the solution, a little more nitric acid must be added and the operation continued until all are dissolved. The silver having been entirely dissolved by the nitric acid, the solution should be poured off and the remaining oxide carefully washed until the last trace of silver is removed. After several washings with a large quantity of pure warm water the latter should finally be tested with a clear solution of common salt, and if it remains clear, without show of milkiness, the silver is all removed. When the oxide is sufficiently washed the purple of Cassius should be dried by gently heating, after which it is ready to be incorporated with the silicious materials.

The process of making gum-enamel is divided into three stages: First, the preparation of the oxide; second, fritting, or by the aid of heat uniting the metallic oxide with the silicious base; and third, diluting the frit so as to form the desired shade. The frit is formed

[1] The dry method of preparing purple of Cassius and the process of manufacturing the gum-enamel were imparted to the author by the late Professor Wildman, who originated it, and to whom is due the credit of having brought the preparation of bodies and enamels to their present high state of excellence.

by mixing 8 grains of the metallic oxide (purple of Cassius) with 700 grains of feldspar and 175 grains of a flux compound of pure quartz 4 oz., glass of borax 1 oz., potassium carbonate 1 oz., fused into a glass and ground fine. The oxide is placed in a smooth Wedgwood mortar and ground separately as fine as it is possible to get it. The flux is then added in small quantities and the levigation continued, after which the feldspar may be added and treated similarly. It is of the highest importance that the mass be reduced to the utmost degree of fineness, and an expert workman will spend six or eight hours at least in levigating the quantity given in the formula. While the mass is being ground in the mortar foreign substances, such as small particles of wood, etc., must be carefully excluded; otherwise during the vitrefying process these will be converted into carbon, which will be sure to reduce a portion of the gold in fine metallic globules distributed throughout the mass.

The vitrefying or fritting process consists in packing the mass, after the most thorough levigation, in the whitest sand crucible that can be obtained. (Dark-colored crucibles are liable to injure the frit by contamination with iron.) This must be provided with an accurately fitting cover made of the same material, or a suitable top may be formed of a piece of slide such as is used in burning continuous-gum work. Before placing the frit in the crucible the interior surface of the latter should receive a thin coating of very fine quartz, made into a paste with water, to prevent the frit from adhering to it during fusion. The frit in the dry state is then packed in, and the cover tightly luted to its place with kaolin. The crucible is then to be buried in a strong anthracite-coal fire, and to remain there until the contents are fused. The time required to do this will depend upon the size of the crucible and the intensity of the heat. Any ordinary coal-stove provided with a good draught will answer, but the fuel must be packed around and over the crucible, and the heat carried to the highest attainable point. Usually about two hours will be required to thoroughly fuse the mass, after which it is removed from the fire and permitted to cool.

The vitrefied mass is removed from the crucible by breaking the latter. Every particle of adhering quartz or portions of the crucible should be cleared from the surface. It is then pulverized to a fineness which will allow it to pass through a No. 10 bolting-cloth sieve, and is ready for the third stage in the preparation of gum-enamel, which consists of diluting the frit with the proper amount of feldspar. As the strength of the coloring pigment varies according to the degree of fineness attained during the levigation, it is usually necessary to make several tests in order to arrive at the desired shade. This is accomplished by mixing separately several different lots in the following proportions:

Gum frit	1 part;	Gum frit	1 part;	Gum frit	1 part;
Feldspar	2 parts.	Feldspar	3 parts.	Feldspar	4 parts.

These are applied to marked pieces of porcelain body and fused in the usual way, the result determining the proportions necessary to produce the desired shade.

White bottle-glass, which does not contain lead or iron, may be used as "flux" to reduce the fusing-point of enamels, but, owing to the uncertainty of the composition of glass, most of the manufacturers of porcelain teeth make a fine glass for this purpose after the formula given on p. 467, the ingredients of which are first ground separately, then thoroughly mixed, and placed in a white crucible provided with a cover (which must be tightly luted) and thoroughly fused. If perfectly pure materials are used, the result will be an exceedingly brilliant, colorless, and transparent glass.

Formulas for Continuous-gum Work.

Bodies and enamels intended for use in the "continuous-gum" process must necessarily be more fusible than the materials of which teeth are composed, in order that the latter may not be affected by the three heatings the denture must be exposed to before it is completed. It will therefore be noticed that an unusual amount of flux enters into their composition. The formulas herein given are those of well-known experts in continuous-gum work, and for further information in the compounding of this class of bodies and gum-enamels, their application and management during vitrefaction, the reader is referred to the chapter on "Continuous-gum Work."

Continuous-gum Formulas of Dr. Hunter.

Flux:	Quartz	8 oz.	Fuse in crucible to form glass; when cold reduce to powder.
	Calcined borax	4 "	
	Caustic potash	1 "	
Granulated Body:	Spar	2 oz.	Fuse in crucible, and powder to pass through No. 50 wire sieve.
	Quartz	1½ "	
	Kaolin	½ "	
Body:	Flux, as above	1 oz.	Grind the first two articles very fine, then add granulated body, which is mixed with the fine without grinding.
	Asbestos	2 "	
	Granulated body	1½ "	
Gum Enamel:	Flux, as above	1 oz.	Grind very fine and semi-fuse in crucible; powder coarsely for use.
	Fused spar	1 "	
	English rose-red	40 gr.	

Formulas of Dr. D. D. Smith.

Granulated Body:	Quartz	20 gr.	Grind fine and fuse on slide in furnace; powder coarsely for use.
	Spar	24 "	
	Caustic potash	1 "	
	Titanium	2 gr.–1 oz.	
Flux:	Quartz, very fine	18 dwt.	Fuse same as above, and grind very fine.
	Spar	10 "	
	Glass of borax	2 "	
	Cryolite	1 "	
	Caustic potash	10 gr.	
	Titanium	1½ gr.–1 oz.	
Gum Enamel:	Gum frit of (S. S. White)	4½ dwt.	Fuse and grind for use.
	Flux without titanium	16 "	
	Granulated body	11 "	
	Cryolite	7 "	

Dr. Moffit's Formula for Continuous-gum Body.

Body:	Spar	12 oz.	Grind coarsely.
	Quartz	$4\frac{1}{2}$ "	
	Bohemian glass	60 gr.	
	French china	35 "	
	German clay	2 dwt.	

No gum-enamel formula came with this. Dr. Smith's formula for gum enamel will do for the above, minus the cryolite.

Dr. John Allen's First Formulas, now Out of Use.

Body:	Quartz	2 parts.	*Gum Enamel:*	Spar	$1\frac{1}{2}$ oz.
	Flint glass	1 part.		White glass	1 "
	Borax	1 "		Oxide of gold	$1\frac{1}{2}$ gr.
	Wedgwood	$1\frac{1}{2}$ parts.			
	Asbestos	2 oz.			
	Spar	2 "			
	Kaolin	1 "			

(For the formula of Dr. Ambler Tees see Chapter on Continuous Gum Work.)

Shapes and Sizes of Teeth.

Though no rules can be formulated by which the dentist can be directed with precision in the congruous selection and arrangement of the artificial substitutes, yet there are always to be found certain temperamental characteristics of the face and personnel of the patient, together with age and sex, which will be of much value in this branch of prosthetic dentistry.

The study of the harmony of temperament with the shape, color, and arrangement of human teeth should claim careful attention on the part of the manufacturer of artificial teeth, and a knowledge of the teeth of the basal temperaments which are the foundation types will materially aid him in the production of life-like forms and colors.

It is true that amongst patients we rarely find pure types of the different basal temperaments, but it would be difficult, if not impossible, to recognize the numerous modifications of the temperamental characteristics of teeth had we not to a certain extent studied the teeth of these types. The following tables give the relation of shape and color of teeth to each basal temperament:

Bilious Temperament.

Color:
Golden yellow.
Shape:
Flat face, large and angular.

Sanguine Temperament.

Color:
Soft yellow.
Shape:
Round face and bold.

Nervous Temperament.

Color:
Transparent blue or gray.
Shape:
Graceful, semi-round face.

Lymphatic Temperament.

Color:
Opaque white.
Shape:
Spheroidal, broad, and rather short.

There are numerous modifications or combinations of the basal types, and the artistic element in prosthetic dentistry consists in the ability to

appropriately select such samples of size, shape, and color as will be in harmony with the facial peculiarities of the patient.

Individuals of the bilious temperament usually have large and rather long teeth, nearly as broad at the necks as at the cutting edges, which are square and well defined. The teeth of the sanguine temperament are smaller in size, distinctly convex on their faces, and tapering at their necks. Teeth belonging to the nervous types are usually inclined to be long and slender, with convex or rounded faces, narrow necks, well-marked longitudinal indentations, and much more delicate and graceful in form and outline than the preceding types. Lastly, types of teeth of the lymphatic temperament are broad and short, with very convex faces, and are without any of the graceful lines of those of the nervous type.

Dr. William R. Hall, who has had extensive experience in the manufacture of porcelain teeth, finding that the descriptions of the teeth of the four basal temperaments, while affording a general idea of size and shape, were not definite enough to be of much use practically, collected a large number of natural teeth for the purpose of ascertaining as nearly as possible the correct outline, exact sizes, and other characteristics of the natural organs, for the purpose of adopting some order or system that would serve as a more reliable guide in the production of life-like imitations of human teeth than did the old plan of one unvarying shape of different sizes, which was the rule before and up to 1865.

Amongst the teeth examined by Dr. Hall were sixteen sets of upper front teeth, such as were previously imported from Europe for pivoting: many of them had probably been purchased from peasants and were well matched as to their relative sizes. In assorting these teeth into groups it was found that there were three distinct and characteristic shapes, representing dissimilar types. They were therefore divided into three classes, which have been found to embrace, practically, all the desirable forms which would be likely to be demanded in prosthetic dentistry.

In the study of this classification it is well to begin with an examination of the crowns of incisors, bicuspids, and molars of both upper and lower jaws—first, because these are indications of shape and temperament; and secondly, with the view to acquiring an intimate knowledge of their forms and arrangement, so that in carving or mould-making they may be designed in such manner with reference to occlusion that they will, when articulated and adjusted to the mouth, perform the function of mastication with some degree of satisfaction to the patient—a result at present not invariably obtained. This is a part of the process of making artificial teeth to which but little attention has been given. Until the publication of Dr. W. G. A. Bonwill's admirable system of articulating porcelain teeth no important improvement had been suggested, and, although Bonwill described his method more than a quarter of a century ago, it has not yet received the recognition either by the dentist or manufacturer to which it is entitled.

The teeth of the first class are those with round or convex faces, the greatest convexity being from the proximate surfaces, with the lesser convexity from the neck to cutting edge. Teeth of this class have necks inclined to be broad.

In the second class were found teeth with semi-round faces, graceful

in outline, narrower necks, and much less rounding on their labial surfaces than the preceding.

The third class consisted of flat-faced teeth, more angular, with square forms, and no appearance of grace in their outlines.

It must not be supposed that the teeth in each of these classes were of the same size: on the contrary, they varied greatly in that respect, both in width and length of crowns, as well as in width and narrowness of the necks. This necessitated a further subdivision of the three classes: accordingly, the maximum and minimum widths and lengths of the crowns were measured and noted in forty-eighths of an inch, this fractional part of an inch being chosen on account of its convenience and the ease with which it may be discerned by the eye. Impressions of the convexities of the faces and outlines of the proximate surfaces were taken in plaster for the purpose of making working models to be carefully kept as future guides.

The maximum size of the superior central incisors was found to be 20 forty-eighths of an inch in width at their cutting edges; the crowns from cutting edge to neck measured 24 forty-eighths of an inch in length; while the widths of the necks varied from 16 to 18 forty-eighths of an inch.

The cutting edges of the smallest central incisors measured 14 forty-eighths of an inch in width and 16 forty-eighths in length of crown; while the necks measured from 10 to 12 forty-eighths in width.

In studying the relative sizes it was found that the superior lateral incisors were uniformly two sizes smaller in length and width than the centrals of the same set—a size being 1 forty-eighth of an inch. The superior cuspids were of the same length as the centrals, and about one size narrower. The bicuspids were four sizes narrower and two sizes shorter than the centrals. The relative size of the molars of a set of anterior teeth given above would probably be from 18 to 22 forty-eighths of an inch in width and from 14 to 18 in length. In general the outer or buccal cusps of the bicuspids and molars are longer than the palatal.

Lower teeth, according to the result of Hall's investigations, vary somewhat in form, but the varieties of shapes are not as numerous as those found in upper sets. He, however, made two distinct classifications—the round and flat-faced with narrow necks, and the round with broad necks. The widths of the lower centrals were from 7 to 10 forty-eighths of an inch, the length from 16 to 20 forty-eighths. The lower laterals were of the same length as the centrals, but in width they exceeded them by two sizes. The lower cuspids were two sizes wider than the laterals and one size longer. The bicuspids and molars will not be found to differ greatly in length and width from the upper teeth of the same set, but in lower dentures the inner cusps are generally longer than the outer ones.

The following is a table[1] of widths derived from measurement of natural teeth herein described. These widths apply to all the three classes, and are believed to be sufficient in range to meet all ordinary requirements. The No. 1 centrals, laterals, cuspids, bicuspids, and molars form one set; No. 2, a narrower set: No. 3, still narrower; and so on to No. 5:

[1] *American System of Dentistry.*

Widths for all Classes of Teeth.

Centrals	No. 1, $\frac{18}{48}$;	No. 2, $\frac{17}{48}$;	No. 3, $\frac{16}{48}$;	No. 4, $\frac{15}{48}$;	No. 5, $\frac{14}{48}$.
Laterals	" $\frac{16}{48}$;	" $\frac{15}{48}$;	" $\frac{14}{48}$;	" $\frac{13}{48}$;	" $\frac{12}{48}$.
Canines	" $\frac{17}{48}$;	" $\frac{16}{48}$;	" $\frac{15}{48}$;	" $\frac{14}{48}$;	" $\frac{13}{48}$.
Bicuspids	" $\frac{14}{48}$;	" $\frac{13}{48}$;	" $\frac{12}{48}$.		
Molars	" $\frac{22}{48}$;	" $\frac{20}{48}$;	" $\frac{18}{48}$.		

Below is a list of thirty additional sets needed to complete the scheme described in the foregoing classifications. This number of sets are thus augmented to ninety, making an assortment of plain teeth large enough for all practical purposes:

First Class: *Round Face, with Broad Necks.*

Five sets, widths as numbered, 1, 2, 3, 4, 5, and $\frac{24}{48}$ long.
" " " " $\frac{20}{48}$ "
" " " " $\frac{16}{48}$ "

Narrow Necks.

Five sets, widths as numbered, 1, 2, 3, 4, 5, and $\frac{24}{48}$ long.
" " " " $\frac{20}{48}$ "
" " " " $\frac{16}{48}$ "

These thirty sets constitute all of the first class.

Second Class: *Semi-round Face, with Broad Necks.*

Five sets, widths as numbered, 1, 2, 3, 4, 5, and $\frac{24}{48}$ long.
" " " " $\frac{20}{48}$ "
" " " " $\frac{16}{48}$ "

Narrow Necks.

Five sets, widths as numbered, 1, 2, 3, 4, 5, and $\frac{24}{48}$ long.
" " " " $\frac{20}{48}$ "
" " " " $\frac{16}{48}$ "

Thirty more sets, constituting all of the second class.

Third Class: *Flat Face, Broad Necks.*

Five sets, widths as numbered, 1, 2, 3, 4, 5, and $\frac{24}{48}$ long.
" " " " $\frac{20}{48}$ "
" " " " $\frac{16}{48}$ "

Narrow Necks.

Five sets, widths as numbered, 1, 2, 3, 4, 5, and $\frac{24}{48}$ long.
" " " " $\frac{20}{48}$ "
" " " " $\frac{16}{48}$ "

While the study of the foregoing classification of shapes and sizes would be a great help to manufacturers of artificial teeth, it must not be supposed that even the most intimate knowledge of it or of any other system will reduce the selection and assembling of the porcelain substitutes and their adjustment to the mouths of patients to an ordinary mechanical operation. From this system of Dr. Hall there are doubtless almost unlimited deviations, and it was clearly his aim in making the classification and measurements to place within the reach of manufacturers a practical plan which might take the place of the haphazard methods heretofore pursued in that branch of industry. Beyond a certain point the interests of the manufacturers and the wants of the dentist are neither identical nor reciprocal. The latter often needs teeth imitating irregularities of position, color, etc. designed for special cases, the production of which the manufacturer is not prepared to attempt, as

it would compel him to depart from the routine work of his factory—a course which he would find unremunerative; hence the dentist must depend much upon his own artistic taste and skill in making such changes in the shapes and positions of the teeth obtained from the manufacturers as the case in hand demands. This can be better done with single plain teeth than with either sectional-block or single gum teeth. It is to be regretted that more attention has not been given to imitating in sectional-block teeth the changes characteristic of age, such as the recession of the gums, which begins in many cases in early middle life and progresses until a large part of the dentine above the crown is uncovered; the loss of that uniformity of color which contributes so much to the beauty of the teeth in youth; and the changes which take place at the cutting edges of teeth as years advance. The absence of these details is largely the cause of the gradual discontinuance of the use of sectional blocks. Really artistic teeth in blocks or sections should cost no more to produce, after the designs and moulds are made, than do the inartistic and conventional sets which we find in such abundance at the manufacturer's.

Unusual shapes of teeth are sometimes demanded for special cases, when the prosthetic dentist must depend upon his own resources for their production. We occasionally need exaggerated examples of teeth of the third class referred to on p. 227, described as flat-faced, wherein the flatness goes so far as to nearly constitute a concavity of the face of the tooth. When this is the case it will be found impossible to secure such teeth from the dental dépôts, and the dentist must depend upon the corundum wheel, with which he may make such changes as are required. This may be done by using a wheel of the finest grit, after which the ground surface of the porcelain may be polished with a small wheel made of Arkansas stone, followed by a small wooden wheel armed with oxide of tin mixed with water. This may be done with the teeth of any of the manufacturers, but it is especially successful when teeth of English make are used, they being formed of porcelain of such closeness of texture that they may be ground and polished without any material change in the surface.

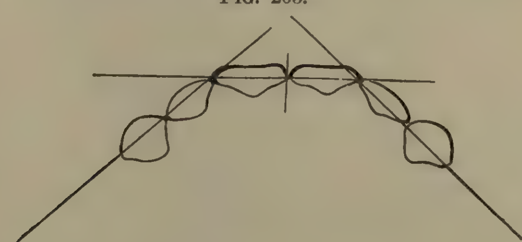
On the other hand, it is sometimes necessary to make additions to teeth in order to bring their forms to correspond with unusual shapes of remaining natural organs. An instance of this occurred recently in the author's practice, in which he found it impossible to match the shapes of some very peculiar lower incisors. These teeth had from early childhood projected so far beyond the upper incisors as to be practically useless in the incision of food; as a consequence, the corrugations which are seen in the incisor teeth of children were still present, although the patient was nearly fifty years of age. The natural teeth had become so loosened that their loss was a question of a short time; they were broad at the cutting edges and unusually round on their faces. This prominence made them a noticeable feature of the patient's face, and after the first attempt to substitute porcelain teeth it was seen that any departure from the form and size of the natural organs greatly changed the expression of the mouth. The difficulty was finally overcome by selecting the exact color from the enamels furnished with the "Downey furnace," described on p. 260. The faces of the teeth were built upon with this

material, which fuses at a much lower degree of heat than do the bodies and enamels of ordinary porcelain teeth. They were then burned separately in the Downey furnace of the pattern recommended for crown-work, the corrugations having previously been cut in them with a corundum wheel. The result was so successful that it established the value of the Downey furnace as a most useful accessory of the author's laboratory.

The relative positions of teeth in the present state of tooth manufacture belongs almost exclusively to the dentist himself. In the assembling of fourteen teeth in the construction of an upper artificial denture he should bear in mind that teeth are lost through two principal causes—namely, the ravages of decay and premature loosening (pyorrhœa alveolaris). In the first case, decay usually begins early in life, and generally before the teeth are finally lost some have become devitalized—a condition necessarily accompanied by change in color. This is an important feature in the general effect of an artistically arranged denture, and the almost total neglect on the part of both manufacturer and dentist to imitate it is one of the prominent causes for the glaring unnaturalness of their products.

Teeth of the frailest class, which have been constantly filled and refilled up to middle age, will generally be found to have lost much of the appearance of regularity which they may have had in early youth. These defects should to a certain extent be imitated. To be natural in appearance teeth must be inconspicuous, in the sense that they must not attract unusual notice. What then could be more startling to the friends and relatives of a patient, whose teeth had always required constant attention on the part of the dentist, than for him to suddenly appear with a denture of pearly whiteness, painfully regular, and in all respects better suited to the age of sixteen or eighteen than to late middle life?

FIG. 263.

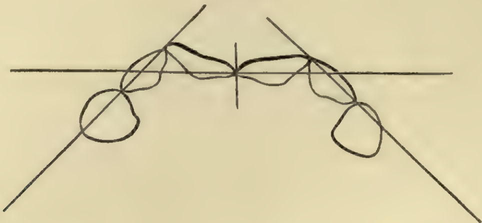


In the arrangement of teeth serious errors are constantly made by the dentist. The work is usually considered well done if a perfectly symmetrical arch has been obtained, whereas in life we rarely find a faultlessly regular arch.

Referring again to the classifications of shapes and sizes which have been considered, we not unfrequently find in the third class the flat-faced, angular teeth of that type standing perpendicularly or nearly so, and at their distal approximate sides either quite straight (Fig. 263) or turned slightly outward (Fig. 264). In the first class of round-faced teeth with broad necks the positions of the centrals are nearly perpendicular, with perhaps a slight inclination toward the centre line.

In the second class the teeth will be found to stand with a slight inclination toward the centre line, from which the incisors are the starting-point of a symmetrical curve (Fig. 265).

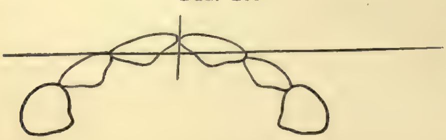
Fig. 264.



In the arrangement of teeth with reference to the inclination of the front teeth backward or forward, corresponding to the conformation of the face, three somewhat hypothetical divisions of physiognomies are made. The first class is a type of the Anglo-Saxons or their Anglo-American descendants : these are described as having oval cranial contour, with forehead slightly sloping, maxillary bones equal in length, the position of the teeth perpendicular or nearly so, to which is due the firm expression of the mouth supposed to be observed in the facial expression of the unmixed native population of the United States.

The second class is not confined to any particular nationality, and is distinguished by poor development of the lower jaw, resulting in a retreating chin. The faces of individuals of this type have a weak expression, and may be found amongst any nation or class of people. Its direct effect upon the teeth is to cause the upper incisors to incline backward to meet the lower teeth. Upper teeth carved or arranged to suit articulations of this class should incline somewhat back of the perpendicular, while the lower teeth should incline forward, so that they may pass just inside of the superior incisors and cuspids.

Fig. 265.



The third type, which is found chiefly amongst a certain class of Celtic origin, is marked by upper and lower jaws of great prominence, causing the teeth to protrude at a sharp angle at the cutting edges. In this facial type both jaws incline forward at an angle of from 70° to 80° ; the upper lip is long and without graceful curves.

The facial types above considered refer to individuals with full dentures, and will serve in a general way to illustrate the inclinations which may be found necessary to the maintenance of the natural expression of the patient's face.

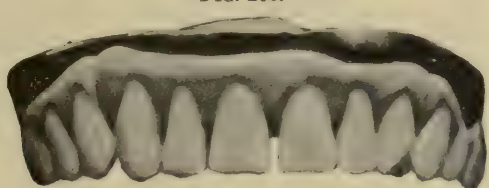
There is another point of importance in the manufacture and arrangement of artificial teeth which deserves notice before the details of their production are considered. This is the fact that in nearly all normal natural dentures the teeth are in contact and each tooth supports its neighbor. Teeth that stand alone and are without lateral support are

liable to become loosened by the strain of mastication. It is evident that this provision of nature is for the purpose of preventing too much force from being thrown upon the socket of any one tooth, yet all the sectional-block teeth that are made have permanent separations between them. Natural teeth with separations, when such a condition in the positions of teeth does occasionally occur, impart a peculiar expression to the mouth and face, and porcelain teeth so arranged are at once recognized as artificial. Spaces should never be made between artificial teeth unless it be done to imitate a similar peculiarity previously existing in the natural denture.

Carving Block Teeth.

The early workers in this art seem to have striven for entirely different results. The object of one worker was to compound bodies and enamels which would maintain their form during the vitrefying process, regardless of color, translucency, and texture ; that of another, the securing of all these qualities at the expense of stability during burning. Fig. 266 shows a set of teeth carved by Joseph E. McIlhenny about 1835 ; Fig. 267 represents a block carved by Prof. Wildman some years later. The first has maintained the form and position of the teeth while fusing, but the amount of clay used to secure these qualities has imparted to the teeth the opaque and cloudy appearance sometimes seen in devitalized

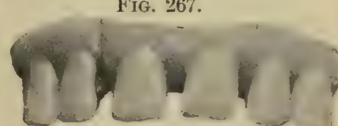
Fig. 266.



Showing faces of front teeth, carved by J. E. McIlhenny.

teeth. In the block carved by Prof. Wildman the teeth have graceful lines, and in color, translucency, and life-like texture have not been excelled up to this time ; but the great spaces between the teeth due to shrinkage of the body gives them a most unnatural appearance.

Fig. 267.



Block carved by Prof. Wildman, showing spaces caused by shrinkage of body.

The carved teeth of fifty years ago were generally arranged with holes through them for riveting. Both of the specimens of the work of Wildman and McIlhenny were so constructed, as shown in Fig. 268. This was done to avoid the danger of fracture during "heating up" preparatory to soldering. As improvements were made in the composition of bodies and enamels the quality necessary to enable them to withstand high temperatures was secured without loss of life-like color and texture.

Carving block teeth is a delicate art, requiring skill, experience, and artistic taste. The simplest natural objects need skill and training in their imitation. The beginner need not expect to faithfully reproduce

the forms of natural teeth in porcelain without first having studied the shapes of many different types of those organs, when, if he possesses artistic ability, more or less success may attend his efforts.

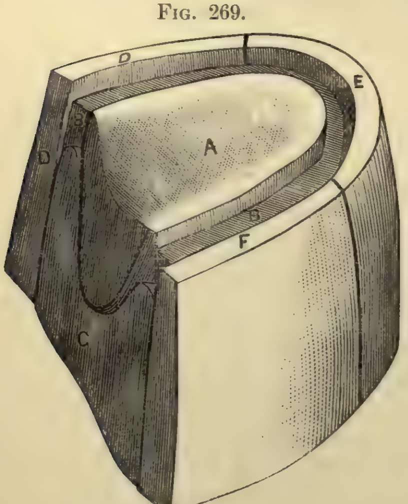
Fig. 268.

Showing arrangement for uniting blocks to plates: teeth made by McIlhenny.

Hand-carved blocks have not reached a very high standard as reproductions of the natural organs, and are inferior from an artistic standpoint to the sectional-block teeth of the best manufacturers of the present time. The works of the few carvers who have given their attention to this branch of tooth-making are exceedingly conventional, and vary only in size: hence carved block teeth have become nearly obsolete. In carved work the liability to warpage and "sprawling" of the teeth is greater than in moulded work, and chance has much to do with the final result.

Where teeth are to be carved for special cases it is necessary to first finish the plate, and then obtain the wax articulation, care being taken to get the exact height and fulness required by the case. The correct centre line is then to be marked. The plate, with the trimmed wax, is placed on the plaster model: in the sides of the model concave retaining-points are cut to assist in retaining the outside walls of plaster, the formation of which is the next step in the operation. The model is then varnished, allowed to dry thoroughly, and then oiled. The plaster is mixed rather thick and built upon the model with a steel spatula until it entirely covers model and wax articulation to the thickness of half an inch: it should extend above the edge of the wax to a little more than one-eighth of the proposed length of the block, to allow for shrinkage in burning.

Fig. 269.

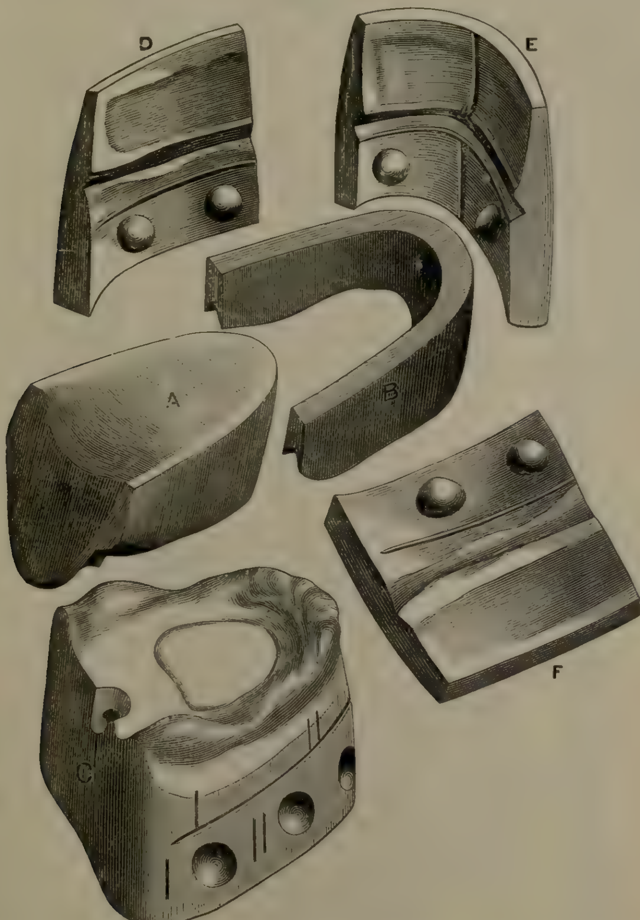


The walls are usually made in three sections, the two side walls being made first, and the front wall next, each wall being made somewhat longer than the required length of the block, to compensate for shrinkage. A vent-groove must be cut at and below the edge of the gum to receive the excess of body (Fig. 270). The surface of the walls against which the plastic body is to be moulded must be lined with tin-foil, made to adhere to the plaster by means of shellac varnish. The inside wall is made by building a

mass of plaster upon the plate and against the inside of the articulating wax. This should also be lined with tin-foil. Fig. 269 shows the cast with the articulating wax, the inside wall (*A*), and outside walls (*D E F*) in position.

Fig. 270 shows all the pieces separately—the inside wall by A; the articulating wax by *B*; the model by *C*; the inside walls by *D E F*; the vent-grooves by the dark line in the three latter.

Fig. 270.

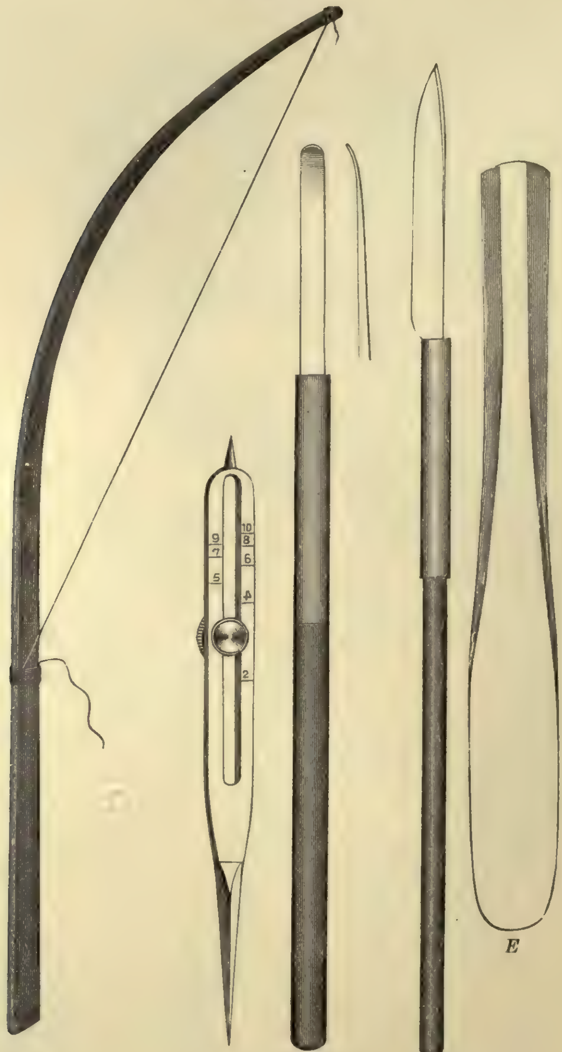


Mixing and Moulding the Body.—The dry body is mixed with perfectly clear water, to which has been added gum tragacanth, 8 grains to the pound of body. Freshly mixed body is too friable for either moulding or handling. It, however, acquires plasticity and toughness by age, and is greatly improved by being kept wet for several weeks before using.

The composition is mixed in a suitable porcelain or glass vessel to the consistency of cream, and poured into a porcelain bowl and allowed to

settle. When the water on top is quite clear it is drained off by tipping the bowl, care being taken to prevent any of the composition from flowing out with it. To prevent any of the coarser parts of the body from settling to the bottom, it must be mixed again very thoroughly by means of an ivory or bone spatula: this must be done with the utmost care, to prevent air-bubbles from being confined in the body, as such an accident

Fig. 271.



A *B* *C* *D* *E*

Carving instruments.

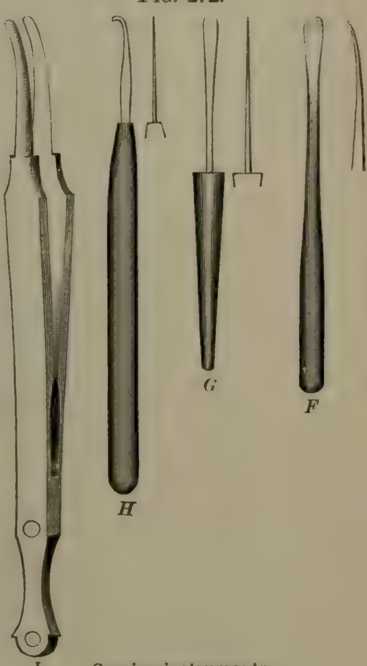
might be the cause of complete failure of one of the blocks; for if the smallest portion of air becomes enclosed in the block and escapes detection, it may expand enormously during the burning process and distort

the block beyond remedy. The jarring caused by gently pounding the bowl on the table will often induce disengagement of air-bubbles and force them to the top. The body is next to be freed of its surplus moisture by gentle heat, which also further assists in the expulsion of air. When it acquires the consistency of fresh putty pieces can be cut off as required for moulding. The remainder must be kept tightly covered, and sufficient water occasionally added to keep the mass plastic.

The inside wall, *A*, is now placed in position, and, together with the outside wall, *E*, and that portion of the plate to be covered by the block, given a thin coat of olive oil. A piece of body somewhat larger than is required in the formation of the block is cut from the mass and worked with the fingers to a convenient shape on a slab of plate glass or porcelain tile: by a sliding motion it is then lifted from the slab and placed on the model, and with the fingers worked against the inside wall in the space upon the ridge previously occupied by the articulating wax, *B*. The outside wall is now quickly applied with sufficient firmness to bring it quite close to the model; the vent-groove shown by the dark line on the walls in Fig. 270 will prevent any resistance being met with in the surplus body, which otherwise might be forced between the wall and model.

The walls are held in position until the body is dry enough for their safe removal. The drying is done by applying heat to the outside of the walls with the flame of a spirit-lamp: the walls are then removed, and the moulded block lifted with great care from the model and placed under a bell-glass until needed.

Fig. 272.



Carving instruments.

Tools Used in Carving Blocks.—These are few in number and simple in character. Figs. 271 and 272 represent the carving tools: *D*, a small penknife blade set in a handle of cedar or poplar wood on account of its lightness, is the carving knife and performs the greater part of the work; *A*, string bow formed by stretching a piece of fine cotton thread across the bend of a piece of whalebone about 7 inches in length; *B*, proportional dividers, shown half size in the illustration; *C*, enamel tool; *E*, bone spatula; *F*, spoon scraper; *G*, drill, made by flattening and tempering a piece of steel wire; *H*, excavators for cavities; *I*, pin-tweezers. The cuts give actual sizes of all the instruments except the dividers.

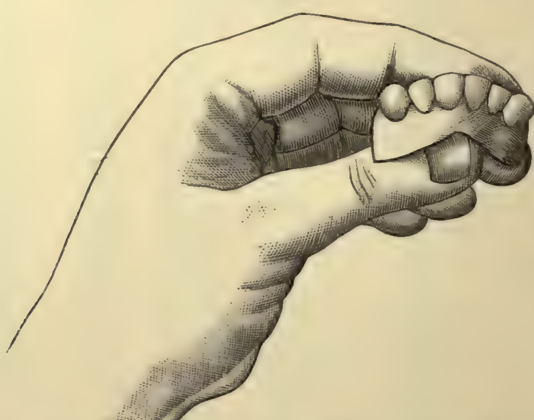
All bodies contract in burning, the amount of contraction depending to some extent upon their composition and the amount of compression they receive before burning: thus, carved blocks will contract about one-

sixth of their entire bulk, and moulded blocks somewhat less. Hall gives one-eighth as the allowance generally made for shrinkage and loss in grinding to fit the plate after burning, but he refers to the body alone, and does not include in the "one-eighth" given the additional shrinkage of the point enamel added after the shrinkage allowance is made in the carving previous to biscuiting. If the shrinkage were to be measured by instruments of precision, it would probably be found to be about one-sixth.

The allowance for shrinkage is arranged with the proportional dividers set to one-eighth increase, the short points being used to measure the articulating wax from gum edge to articulating edge. The respective distances are marked on the cast as shown on *G*, Fig. 270.

The block is carefully placed on the plate and supported by the inside wall; the proper height with shrinkage allowance is then scribed on it with the adjusted dividers, one point resting in the horizontal line, while the other touches the block. By drawing it gently along the top of the block a distinct mark is made, indicating the point to which it is to be cut down. This cutting down is done by removing the block and lightly grasping it between the thumb and index finger of the left hand, with the middle finger curved under it in a manner to form a cushion or support for it. The knife is then brought into use, and all material above the line made by the dividers cut away. So fragile is the unburned body that the slightest excess of pressure may crush the block: a gentle yet firm handling of the unburned material will, however, come to many workmen with practice, but there are undoubtedly some who never can acquire the ability to go through the different stages of carving an entire upper and lower denture without an accident, for the blocks must be taken up and put down many times before they are ready for the final burning.

FIG. 273.



Method of holding block when carving the labial side.

The widths of teeth are next to be marked off on the block. This is done by first marking the centre line, and then indicating on each side of it, by a shallow incision in the body, the desired size of the centrals:

if the latter be medium in width, the laterals should be two sizes narrower, cuspids one size narrower, than the centrals. In arranging for shrinkage a good plan is to select either a natural or porcelain tooth of the desired size, which, for the sake of example, may be assumed as 16 forty-eighths of an inch wide. The width in carving must be increased to allow for shrinkage, so that after burning the carved teeth will be exactly the size of the sample. To accomplish this the sample tooth is measured by the small points of the dividers; the large points will indicate the increase.

In the first carving no attempt is made to obtain precision of form or full relief, as shown in Fig. 273. The teeth are but superficially laid out, and purposely left flatter than would be desirable when finished. The first step is to cut an inverted Λ-shaped space at the centre line to represent the space between the central teeth: this is repeated between centrals and laterals and laterals and cuspids. The edges are slightly rounded, and by a circular cut of the knife-point the necks of the teeth are formed, while at the same time the correct lengths are given them.

During this preliminary work the block is held gum upward: it is now to be reversed and the points of the gum between the teeth are carved down, and both ends of the blocks cut square for jointing to the side blocks. The inside is then trimmed to the proper thickness, and the sulci or depressions peculiar to the palatal surfaces of incisors and canines are formed with the instrument *F*, shown in Fig. 272. Separations are made with the bow-saw *A* (Fig. 271). The block is then ready for the platinum pins. If the blocks are to be soldered, a level surface is left from the point at which the palatal surfaces of the teeth end to the portion intended to rest upon the plate. Into this level surface holes are drilled for the reception of the pins. These holes are made by rotating a small drill, as shown in *G* (Fig. 272), between the thumb and index finger. The drill, made of a piece of No. 20 steel wire with the end flattened to the width of No. 13 of the standard gauge, will form a hole large enough for the reception of the head of the pin. Two-thirds of the pin should be imbedded in the block. The pins are put in position by means of the tweezers shown in Fig. 272, and a thin mixture of body and water floated around them by means of a small camel's-hair pencil, care being taken that the mixture is carried quite down to the heads of the pins without enclosure of air.

If the blocks are designed for mounting on rubber base, a recess must be made for the pins, as shown in Fig. 275. If the blocks are very fragile, the holes may be drilled and the pins put in after they are biscuit-burned.

Biscuiting.—Biscuit-burning is the partial vitrefying of the blocks by which they are hardened sufficiently to admit of handling without danger of breaking, and, what is even of greater importance, their form is to a certain extent permanently fixed, so that they will not become plastic or semifluid when the wet enamels are laid on them. The blocks are placed on a fire-clay slab called a "slide," and thoroughly dried by gentle heat before they are put in the muffle and exposed to a bright-red heat. The burning must be carried beyond the point where the body can no longer be softened by water, and yet not be too hard to cut. It should remain porous enough to absorb the water from the enamels as

they are laid on, otherwise enamelling will be found impossible or nearly so. The slightest glazing of the surface must be avoided. About the hardness of a piece of cuttle-fish bone is the proper condition. The biscuited blocks may be cooled in the air without danger of cracking.

Enamelling.—Enamels should be kept in small glass jars provided with tight stoppers to exclude the dust. Each enamel must be carefully kept from accidental admixture with others, and the jars should be labelled with the number, color, and other explanatory remarks written plainly thereon. A small piece of body, with some of the enamel fused on it, may be tied to the jar; this affords absolute accuracy in the determination of the color, when burned, of the contents of each jar.

More failures occur in enamelling than in any other part of block-carving. Great care is constantly required to see that the enamel is laid on of the proper thickness, that it is uniform in quantity, that it does not unite with the body, and that point and base enamels are so applied that a perfect blending of the two colors may result. The coat of enamel on the teeth and gums should be at least $\frac{1}{24}$th of an inch thick; the development of the translucency of the spar and brilliancy of the colors demands at least that quantity. The body, having clay in its composition, is opaque, and would show through a thinner layer of enamel and impart to the teeth a flat and lifeless appearance.

In mixing enamels 15 grains of gum arabic to each ounce of enamel is used, to prevent the coloring materials from settling when mixed with water, to make the enamel work smoothly, and to enable it to be handled when dry without rubbing off.

In addition to the point and base (neck) enamels alluded to in the description of the manufacture of these materials, there is a class of enamels used for staining teeth in imitation of the dark spots on the cutting edges of much-worn incisors and cuspids of middle-aged and elderly patients, and for reproducing in the porcelain teeth the discoloration incident to devitalization of the natural organs, etc. These are usually the darkest shades of brown and olive.

Enamels are mixed with clean water until the mixture presents a cream-like appearance. They are then applied with camel's-hair pencils of different sizes. The first layer is placed on the necks of the teeth, extending to near the cutting edge, tapering in quantity as it approaches the point. In applying the enamel the block is held gum upward, care being taken that the enamel adheres to the body, and, if any creases occur, to wet them down by touching them with a wet camel's-hair brush, and that all ridges be smoothed or trimmed down with the small carving knife.

When the point enamel is applied the block should be reversed, so as to be held with the teeth upward. The brush is partly filled with the point enamel, and applied lightly to the cutting edges of the teeth to the thickness of about $\frac{1}{24}$th of an inch, and carefully worked down with a full brush in the direction of the neck of each tooth. All the neck enamel previously laid on must be quite covered, but the point enamel should be applied very sparingly as it approaches the margin of the gum, full thickness being given at the cutting edge only.

Some experience is required in laying on the point enamel to avoid

wiping off the neck enamel at the same time. It is desirable that the latter should show through the thin layer of the former and be toned and blended by it. To prevent mixing of the two enamels, and the consequent injury to the effect of each, the brush full of enamel should be drawn lightly over the teeth in a manner to allow the enamel to be drawn from off the point of the brush upon the block. The edges may be made even by touching them with a wet camel's-hair brush. It is essential that the enamel be carried well between the teeth.

After completing the enamelling, the carving and shaping is begun by separating the teeth from each other with the string bow. The contour is now carefully formed, the separations at the necks being made by cutting inverted Λ-shaped spaces between them. The block is again reversed with the cutting edges down, and the necks given distinctness by well-directed sweeps of the knife to form the semicircular lines between the necks and the gum. The faces of the teeth are then given the character of the type which they are designed to imitate.

It must be remembered that the tendency of the vitrefying process is to flatten down prominences and to round off corners; therefore all the features and outlines of the teeth should be somewhat exaggerated, so that the finished block may retain the requisite degree of individuality.

Forming the contour of the teeth from the neck to the point is the most important part of the operation of carving, and the style of teeth needed for the case in hand will depend upon the amount of prominence given the enamelled block. With a definite model in mind the carver must take into consideration and anticipate all the changes incident to the burning process.

Some well-thought-out systematic plan for carving teeth, and one that will include the general characteristics of the natural teeth, will be found of great convenience, so that close imitations may be obtained. A small, well-selected collection of natural teeth should be made, such as will serve the purpose to show the wide ranges of sizes and shapes existing in the natural organs.

Gum Enamel.—This enamel requires in mixing at least 20 grains of gum arabic to the ounce of enamel to prevent it from settling to the bottom of the cup on account of its greater coarseness. It is first applied to the festoons between the teeth with the point of the carving knife; the rest is easily put on with the brush, care being taken to carry it close to the necks of the teeth, but not to allow it to overlap the necks. It is not necessary to lay the gum enamel on very smoothly; the result will be better if left rough and somewhat uneven: fusing at a lower temperature than the point enamels, it will take care of itself in burning, and a moderate degree of unevenness of surface tends to produce a natural effect in the finished block.

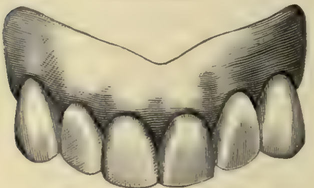
The gumming process in carved work is, as a rule, poorly done. It is not always recognized that the surface of the natural gums have characteristic irregularities and variations in degrees of shade and color. The ridges around the necks of the teeth should be carefully imitated. The shade of the gum is a little deeper between the teeth than immediately over the roots: this should not be overlooked.

The palatal surfaces of the teeth and inner surfaces of the blocks

should be given a thin layer of point enamel to serve as a glazing to the rough surface of the body, after which the blocks are ready for burning, and should be allowed to dry perfectly for that purpose.

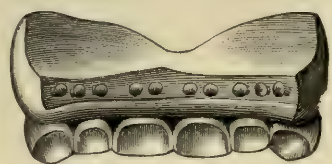
(Figs. 274 and 275 show a finished front block.)

FIG. 274.



Labial side of finished block.

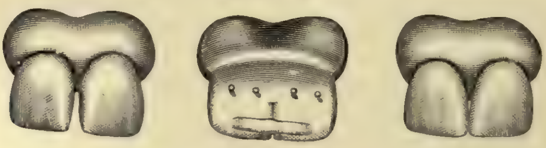
FIG. 275.



Lingual side of finished block.

If the teeth are long, and it is desirable to maintain close contact between centrals, difficulty may be encountered in preventing "spread-

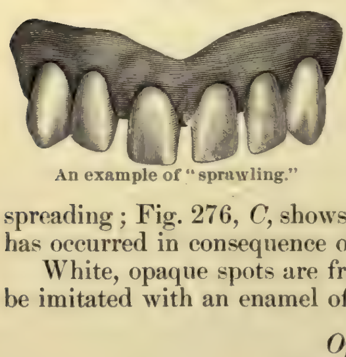
FIG. 276.



A *B* *C*

ing" while burning. This may be prevented by tying the teeth together with a loop of body placed across the separations from one tooth to another. It is done by mixing some body with water, so that it can be applied with a small brush. After the teeth are burned the loop of body can be ground away with the corundum wheel. Fig. 276, *A*, shows the spreading as it often occurs during the burning of a block not so reinforced; Fig. 276, *B*, shows the manner of arranging the body to prevent spreading; Fig. 276, *C*, shows block from same mould in which no change has occurred in consequence of the reinforcement of body on inside.

FIG. 277.



An example of "sprawling."

White, opaque spots are frequently seen on natural teeth: these may be imitated with an enamel of the following proportions:

Opaque Enamel.

Kaolin,	$\frac{1}{3}$ oz.	
Feldspar,	1 "	Mix well.

Before burning small depressions are cut in the soft enamel and filled evenly with the opaque enamel.

Staining Teeth.—To closely imitate certain peculiarities of the natural organs it is sometimes desirable to stain their cutting edges to represent the dark-brown dentine often noticed between the outer and inner plates of enamel in the much-worn teeth of middle-aged men who

have used tobacco; or, again, to occasionally darken a tooth in imitation of the color of teeth in which the pulps have died. The following formulæ may be used where properly indicated:

Dark-greenish Stain:	Platinum sponge,	5 gr.
	Titanium oxide,	10 "
	Feldspar,	10 "
	Enamel flux,	2 "
Dark-yellow Stain:	Titanium oxide,	20 gr.
	Gum frit,	4 "
	Enamel flux,	2 "
Black Stain:	Iron scale,	10 gr.
	Feldspar,	5 dwt.

These stains, like the other enamel frits, vary in depth according to the state of fine division attained; they should be kept in small glass jars, with fused trials fastened outside for reference.

Cavities for filling may be cut with excavators in the biscuited teeth. As a rule, cavities for filling in artificial teeth are objectionable. Occasionally, however, a patient loses a tooth which has been conspicuously filled with gold for a number of years: in such instances its replacement by an ordinary tooth might constitute so noticeable a change as to warrant the attempt to imitate the filled natural tooth.

Other methods have been devised to produce block teeth for special cases with less expenditure of time, and to avoid the liability to accident so common in the plan just described. In the various processes suggested the tendency has been to adopt some plan of moulding instead of carving, and to make the work more a mechanical procedure than one which requires a high degree of artistic talent.

Fig. 278.

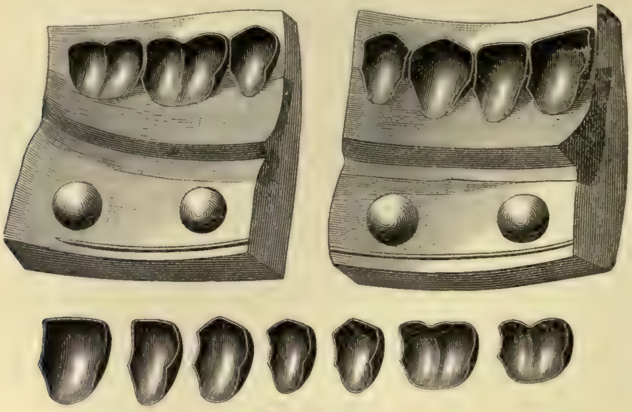
Biscuited teeth.

In one process biscuited plain teeth were placed in position while the body was soft (Fig. 278 gives front and side views of the forms of biscuited teeth designed for this purpose), but this plan has been abandoned on account of the frequent failure of the partly burned teeth to unite with the soft body, which was often only apparent after the teeth were burned.

Another process consists in making movable matrices of different sizes and styles to correspond to the classes of teeth described in this chapter, the object being to do the enamelling and moulding of the entire block in one operation. These matrices are made of very thin sheet

brass, about No. 32, stamped over hard brass or steel dies: the die must necessarily be an accurate copy of the teeth desired, with

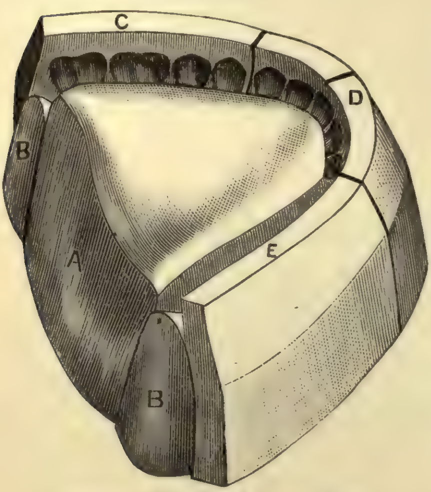
FIG. 279.



Enamel cups.

allowance for shrinkage and other changes incident to burning. These cups are arranged on the wax articulator precisely in the position required in the finished block. Walls of plaster are then made in the manner described on page 232. When hard enough the walls are removed, bringing with them the brass enamel cups, as shown in Fig. 279.

FIG. 280.



Brass cups in position for moulding.

The gum surfaces of the walls are then lined with tin-foil; the enamel cups are to be made fast, should any become detached from the wall, by means of hot wax or resin and wax cement. The cups and walls are then oiled, the enamel is placed in the cups, point enamel first, and then the base. The body is applied the same as in ordinary carved work (Fig. 280).

The heat of a small spirit lamp is applied until the body is dry enough and the wax or cement sufficiently softened to admit of the removal of the wall. The cups will be found adhering to the block: these must be removed without injury to the moulded teeth. Dr. W. R. Hall, to whom is due the credit of devising this method, found the difficulties of making the dies and forming the cups very great, the very large number of the latter needed for a working set, over a thousand being required, complicating instead of simplifying the production of block teeth. On the other hand, the method possesses the advantages

over carved work of affording more perfect and finished teeth, greater facility in their duplication, less liability to accidents, superior density, and uniformity of distribution of the enamels.

Brass Moulds for Porcelain Teeth.—Mould-making is generally thought to require peculiar talents and a high degree of mechanical skill. It certainly does demand artistic talent, but the mechanical part of it is not particularly difficult. It includes the carving of the plaster blocks, making the plaster pattern of the mould, casting it in hard brass or bronze, and the "cutting" or finishing of the mould.

The plaster blocks constitute the design, and are a complete set of block teeth carved in plaster, with allowance made for shrinkage and other changes which take place in the vitrefying process. This part of the work must be done by an artist and one who has knowledge of the several classes of human teeth. These designs should always be made from natural teeth, but the custom amongst manufacturers is to use plaster face-blanks, made from plain teeth moulds, somewhat larger than is needed for the set to be made, to allow for carving to the proper size and shape. The blanks are arranged on a rim of wax similar to articulating wax; the gums are formed of paraffin or the pink combination of paraffin and wax; broad spaces are left between the centrals; the cuspid and first bicuspids and the second bicuspids and first molars, as sectional blocks for an entire upper denture, are divided into six pieces. Each block must be provided with a slight excess of material at the joint, to afford sufficient latitude in fitting them together. A wall of plaster about one-fourth of an inch in thickness is run on the outside of the model, so as to include the entire set of blanks: when hard enough it is trimmed so as not to exceed in height the cutting edges of the tooth blanks, varnished, and oiled; an inside wall is then made of plaster of the same height as the outside one. The inside wall is removed when hard in one piece; the outside one is cut into six pieces with a thin saw-blade, the cut being made between the centrals, the cuspids and bicuspids, and the bicuspids and molars at the spaces shown in Fig. 281. The sections thus made are then separated from the model.

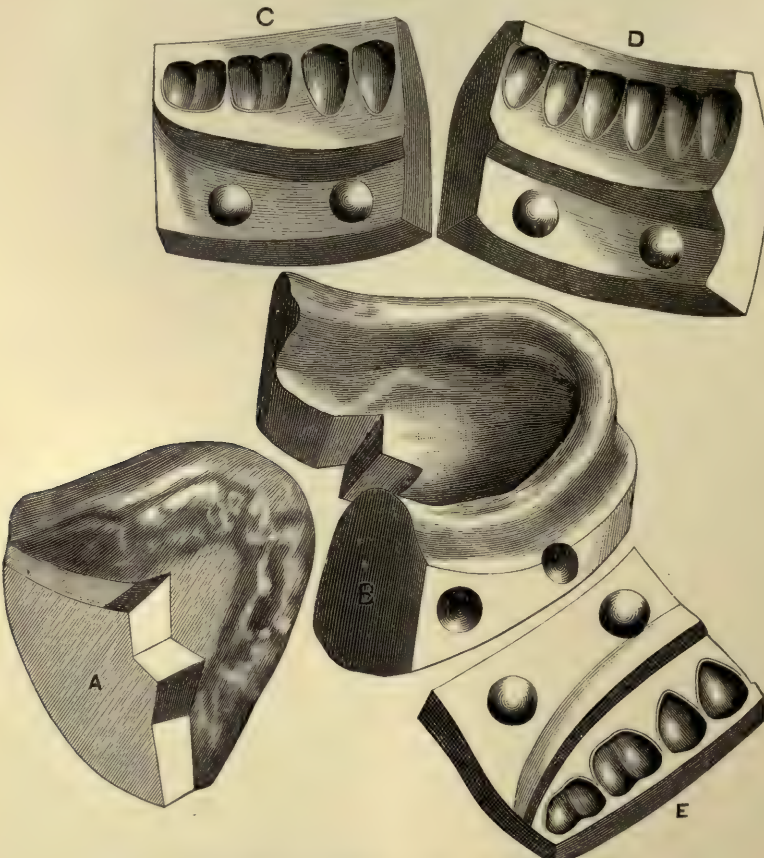
Fig. 281.

Tooth-blanks arranged on cast.

Both the outside and inside walls are trimmed, varnished, and laid aside to dry. The removal of the blanks from the model is next in order, and both walls are given a coating of shellac varnish. Fig. 282 shows the walls made for a lower set of plaster blocks. The walls are now to be placed on the model and secured in position with twine or wire: they are then oiled, and plaster mixed to the consistence of cream is first painted over the surface, as representing the

teeth, with a camel's-hair brush, when the residue is run in between the inside and outside walls and allowed to set thoroughly before removal. If the plaster has been carried into all depressions and interstices between the walls, a continuous set of plaster blocks will be the result. These are separated into six sections by means of a thin saw-

Fig. 282.



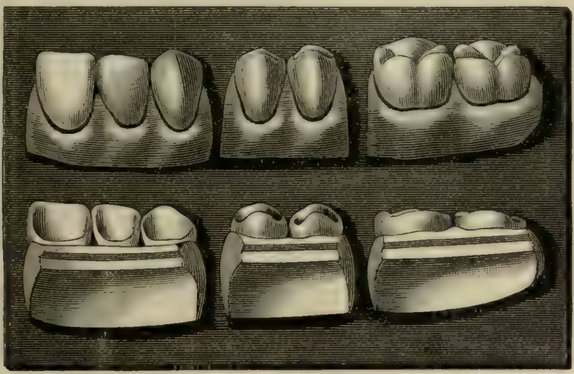
View of the walls and cast, separated.

blade, as shown in Fig. 282, the six front teeth in two sections of three each, the first and second bicuspids of each side in two other sections; the molars are divided in the same way. These plaster blocks now require trimming on the inside, the carving of the masticating surfaces of the bicuspids and molars in imitation of the natural organs, and the cutting of a recess for the pins, as seen in Fig. 283.

The ends of the blocks, or those parts technically called the joints, must be trimmed so that they will taper sufficiently to ensure their safe delivery from the plaster mould, as shown by the pin sides of the plaster blocks in Fig. 283. If not properly bevelled at all points, so that no undue retention will occur, it may be necessary to remove the pattern

blocks piecemeal. The plan of such a mould would then be found to be defective, and, as may readily be surmised, it would not be possible to

Fig. 283.

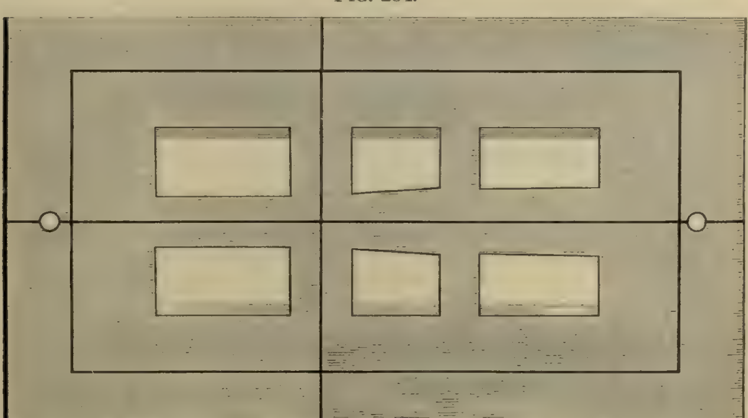


Plaster blocks, finished.

obtain a brass mould from a pattern in which so serious a fault existed. After these details have received careful attention and the blocks have been trimmed and carved to the satisfaction of the workman, they should receive at least two coats of shellac or sandarac varnish.

The Plaster Mould.—The preparation of the plaster mould is the second part of the process of mould-making, the first part being the modelling of the designs in the form of plaster blocks. These designs are really the foundation of the whole system, and require in their production artistic talent and knowledge of the forms of the different types of human teeth. With the exception of the cutting or finishing of the brass mould, the rest of the process is purely mechanical, but the carving

Fig. 284.



Foundation plate.

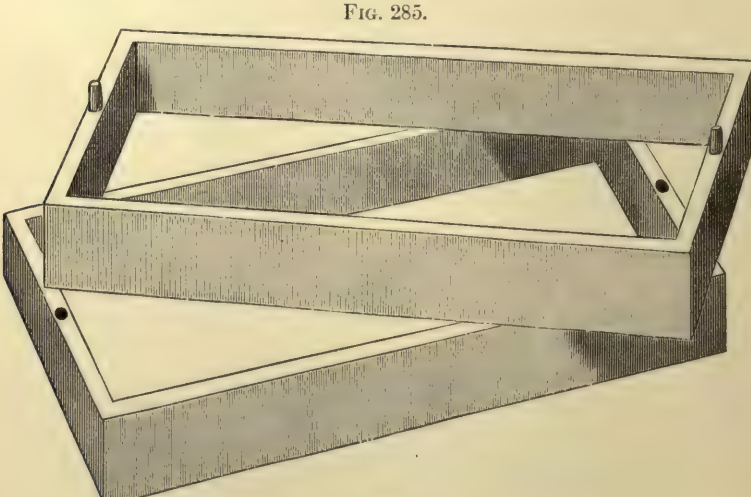
of the models and the finishing of the face sides of the brass moulds should be done by the same hands. The mechanic to whom this part

of the work is usually entrusted is liable to cut out many of the lines and depressions observed in the natural teeth and imitated in the plaster models.

By referring to Figs. 288 and 289 it will be seen that the finished mould consists of five pieces—the face side, the pin side, two end- or crown-pieces, and a key-piece. These pieces have all to be made in plaster to serve as patterns from which to cast facsimiles in brass. The plaster blocks are arranged on a foundation plate. This plate can be made of brass or zinc, as shown in Fig. 284, $5\frac{1}{2}$ inches long, 3 inches wide, and $\frac{1}{4}$ of an inch thick, with oblong recesses to receive the blocks—those for the front blocks 1 inch long and $\frac{1}{2}$ an inch wide; those for the bicuspids, $\frac{3}{4}$ of an inch long and $\frac{1}{2}$ an inch wide; and those for the molars, $\frac{7}{8}$ of an inch long and $\frac{1}{2}$ an inch wide. The black lines on the plate are used as guides to measure from in placing the blocks; the round holes at the ends are to receive the pins seen on the frames in Fig. 285.

The plaster blocks are placed on the foundation plate faces upward, with the cutting edges opposite to each other, as seen in Fig. 286, and are then secured in position with beeswax, clay, or putty, which also marks the correct line of division between the two halves of the mould. This is a very important detail of mould-making; upon its correct management depend the successful application of the enamels and the safe delivery of the moulded porcelain blocks. This line of division should extend along the middle of the cutting edges of the incisors and canines and the gum edge, but should include but little of that portion of the block called the joint. By referring to Fig. 207 the reader will see that the face side of the mould gives merely the distinct outline of the entire face of the block, and that the bulk of the block is represented in the pin side; yet the edges of the face side of the blocks should be sufficiently

FIG. 285.



Brass frame.

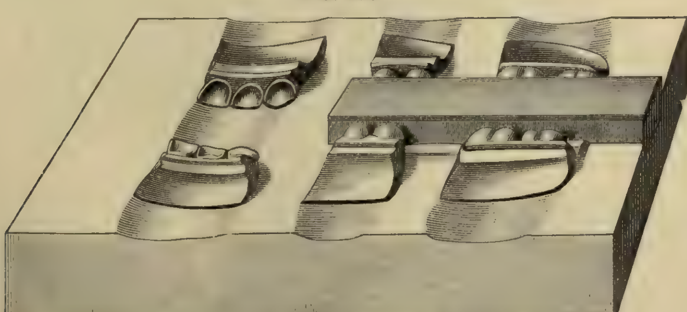
well defined to assist in holding the enamels in position when the mould is pressed together. The front blocks are secured to the plate two six-

teenths of an inch from its centre line; the bicuspid blocks, three-sixteenths of an inch from the line; the molar blocks, four-sixteenths from the line. The side blocks are arranged farther apart at the end near the molars than at the other, to allow for a tapering key, as shown by *C* in Fig. 289. If all spaces between the block and the foundation plate have been stopped with clay or putty, the plate with arranged blocks is ready for the frame.

The frame is in two sections made of polished brass, one section made to articulate with the other by means of pins and corresponding holes, as seen in Fig. 285. The inside tapers so that the plaster mould when hard may deliver without difficulty. These frames measure $4\frac{3}{4}$ inches in length and $2\frac{3}{8}$ inches in width, each section being $\frac{3}{4}$ of an inch high with a thickness of $\frac{1}{4}$ of an inch. The part with pins is well oiled on its inside and placed on the plate. The plaster blocks having been oiled, the plaster is mixed by dropping it into water and allowing it to settle without stirring, so as to exclude air; the excess of water is then poured off; the blocks carefully coated with thin plaster by means of a small camel's-hair pencil; the rest of the plaster is then poured in and levelled off even with the top of the frame with a spatula. When the plaster becomes hard the plate is removed and the face side of the pattern is secured.

The blocks are then carefully taken from the face side of the plaster mould, and, if any of the edges are broken, they must be repaired with wax or plaster and made smooth. After the removal of the blocks the mould must be varnished with shellac or sandarac and allowed to dry thoroughly, when the blocks are replaced. The space between the bicuspid and molar blocks is filled by a piece of wax, as seen in Fig. 286, to form the depression intended for the end-pieces and key in the

Fig. 286.



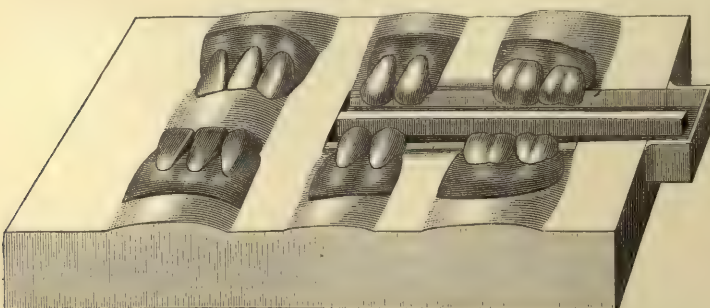
Pin side of plaster mould, with plaster blocks and wax in position.

pin side of the mould. The whole fixture is then thoroughly saturated in clean water, the surfaces coated lightly with oil, and the other section of the brass frame placed in position and filled with plaster mixed and applied in the manner previously described: this forms the pin side of the mould. The two sections are easily separated when the plaster has hardened sufficiently by introducing a knife-blade between them and carefully prying apart. The plaster blocks will usually be found in the pin side of the mould, because the greater portion of the block is embraced in that part of it, and consequently offers more surface for

retention than does the face side. The brass frames are next to be removed from each part of the plaster mould by tapping the former gently with a small wooden mallet. The blocks are then to be removed from the pin side of the mould: this must be done with the greatest care by inserting a sharp excavator or knife-point under the block and gently prying it out. If any part of the mould is broken and carried away with either of the blocks, the piece may be fastened back to its proper place with thick shellac varnish, or, if lost, the defect may be repaired with beeswax.

The crowns or masticating surfaces of the bicuspids and molars are formed by end-pieces held in place by a wedge-shaped piece of brass, as shown by *A*, *B*, and *C*, Fig. 289. The wax seen in Fig. 286 must be taken away from between the side blocks, and the blocks removed and carefully cleaned; the space formed by this piece of wax must be trimmed so as to increase its width about three-sixteenths of an inch, its floor made perfectly flat and its sides perpendicular, and arranged to taper toward the end nearest the front blocks, where it should be slightly narrower than at the molar end of the space. This space at its floor and sides must be level and true, or the crown-pieces and key *A*, *B*, *C* (Fig. 290) will not fit well in the finished mould: the surface of the

Fig. 287.

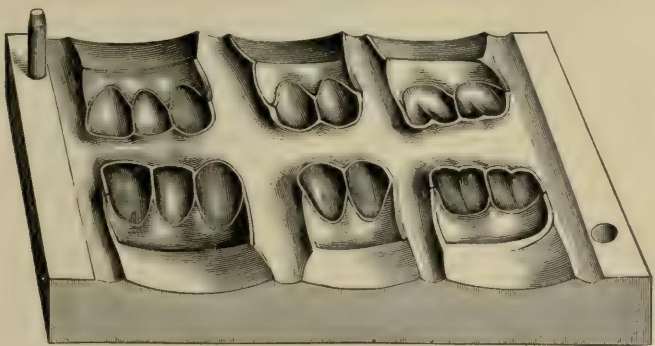


Face side of plaster mould, with temporary key.

recess is then varnished. A temporary key of brass is placed midway in this space and secured with wax, as shown in Fig. 287, and allowed to extend a quarter of an inch beyond the end of the mould. The plaster mould is then oiled and put in water to drive out the air; the side blocks are oiled and put in place; the face side of the mould is oiled and put in position, and the two sides tied together. Plaster, mixed thin, is then run into the spaces on each side of the temporary key extending beyond the mould to the end of the key. After the plaster is hard the temporary key is carefully drawn out by means of pliers, when the crown-pieces may be easily removed. All the parts of the plaster mould are now to be thoroughly dried by gentle heat; grooves are then cut around each block in both sides of the mould to allow for the escape of the excess of body and enamel usual in moulding teeth. All parts of the plaster mould must be made as smooth and perfect as possible, as its condition, whether good or bad, is duplicated in the brass castings, where it is much more difficult to correct imperfections or faults

than in the plaster. When entirely finished and thoroughly dried all the parts of the plaster mould are to be varnished with shellac and

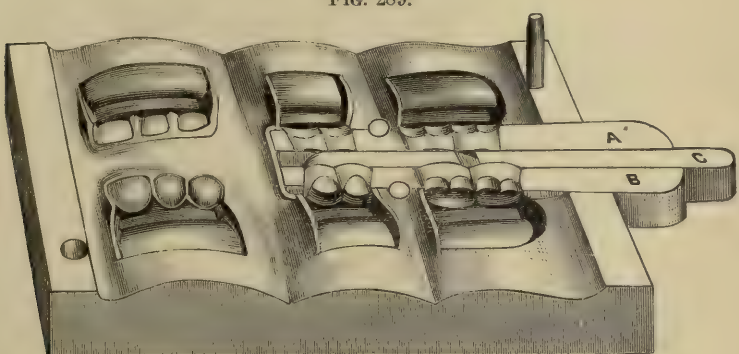
FIG. 288.



Face side of brass mould.

allowed to dry thoroughly, when they are ready to be sent to the foundry to be cast in hard brass.

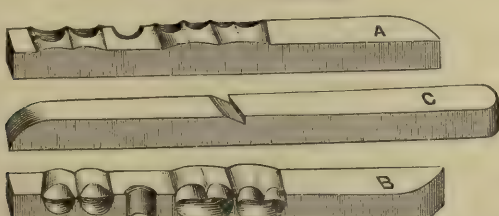
FIG. 289.



Pin side of brass mould.

Fig. 288 shows the face side of the finished brass mould. Fig. 289 shows the pin side, *A* and *B* the crown-piece, *C* the key. Retaining

FIG. 290.



Crown-piece.

Key.

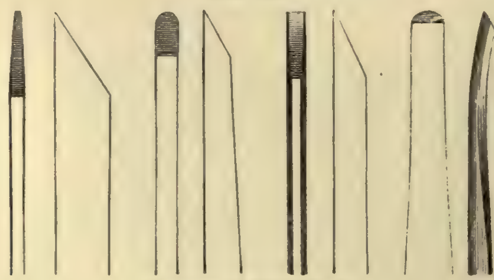
Crown-piece.

pins of brass are put in to prevent movement of the crown-piece during moulding: the heads of these are seen in Fig. 289 between the molar and bicuspid blocks.

Cutting and Finishing Brass Moulds.—Undoubtedly, moulded teeth afford opportunities for better results in the imitation of the natural organs than does carving, but the original designs, as well as the cutting and finishing of the moulds, must be executed by a higher class of workmen than have as yet been entrusted with that exceedingly artistic work. Much of the work of the mould-maker is apparently done rather from habit than through any clear insight into the actual requirements of his task. The horizontal depressions on the faces of the central and lateral incisors are usually too stiff and distinctly defined, while their lines are straight and unnatural. These, however, are defects of execution rather than of the system of mould-production, and will doubtless eventually be remedied.

The tools required in mould-finishing are comprised in the following list: Two or three flat files, 10 or 12 inches long, bastard and smooth-cut, for finishing the outside of the mould; small files, flat and half-round, for the inside; a half-dozen gravers, such as are used by wood-engravers, flat and round-edged, of the different sizes shown in Fig. 291; a bench-vise with jaws about 3 inches wide; an upright breast-

FIG. 291.



Gravers, of Stub's steel.

drill, with three sizes of Morse drills for adjusting the guiding pins; taps and dies for the same; two pairs of steel dividers; a pair of steel callipers; a steel square, 4 inches long, for truing up the mould; a hack saw, for sawing off the pins; a steel clamp, to hold the two sides of the mould together when drilling the holes; a 30-pound anvil; a 4-pound hammer; a taper reamer for the guiding pin-holes.

An unskilful workman can do much harm to the brass mould in the cutting and finishing. The graver should not be used to change the contour or lines of the teeth: any good founder can reproduce all the parts of the plaster mould in brass in so nearly a perfect condition that the gravers will be needed only to finish the surface of the mould, but not to change it. Brass or bronze, like other hard metals, when cast will shrink somewhat, and thus the brass casting becomes smaller than the plaster model of which it is a facsimile: in finishing the surface of the depressed teeth and gums in the brass mould the workman will necessarily enlarge to some extent the reversed representation of the blocks to the original size of the plaster models, and the work should be done with such precision that the latter can be placed in the brass mould and fit as though they had been moulded in it.

A hard bronze, containing about 15 per cent. of tin, is better adapted for moulds than is ordinary brass, as it affords a sharper casting and the requisite degree of hardness to prevent the mould from yielding when exposed to heavy pressure. When the castings are received from the foundry it will be seen that the edges along the line of division of the blocks on the face and pin sides of the mould do not touch when these two parts are placed together: this is due to the unequal contraction of the metal, and must be corrected by filing down the high parts, so that all edges will meet and the two halves of the mould fit together without rocking.

After fitting together the two sides of the mould, trial blocks of plaster should be made, to ascertain if the outlines of the blocks meet properly. The trial blocks, made by pressing plaster between the two halves of the mould, will indicate any defect in adjustment. If, however, it is found that the outline edges are quite together, and that the relation of one half to the other is correct, the guide pins are to be put in, in order that the relation of the parts be permanently fixed. This is done by firmly holding the two parts of the mould in a steel clamp, and then drilling the holes for the pins entirely through each side with a three-sixteenths of an inch drill. One of the guide pins is placed in the face side of the mould opposite the right central, the other in the pin side opposite the left molar. They must be permanently screwed, one in each side of the mould, as shown in Figs. 288 and 289. After the holes are drilled, the one in the face side opposite the central and the one in the pin side opposite the left molar must be screw-tapped to receive the screw end of the guide pins; the other end of the pins must taper slightly near its extremely so as to freely enter the hole opposite to it; but the pins must fit close enough to prevent lateral movement when the two parts of the mould are quite together. These pins should be made of steel wire not less than three-sixteenths of an inch in thickness. The outside of the mould is then to be squared and finished: this may be done either in a lathe or by filing guided by the try-square and callipers, for it is very important that the mould when the two parts are together should be uniform in thickness and perfectly level, as there is danger if these conditions are not secured of its being sprung out of shape by the press in moulding teeth.

The next step toward the completion of the mould is the fitting of the end-pieces in the space between the back blocks: the floor of the space must be filed perfectly flat and level, and the side made perpendicular; the crown-pieces where they are in contact with the key are made smooth and true; the taper key, *C* (Fig. 290), is made to fit between them and holds the crown-pieces securely against the perpendicular walls of the space alluded to above during the operation of moulding teeth. This key is made longer than the crown-pieces, so that it can be driven between them with a wooden mallet to facilitate its removal. To prevent the crown-pieces from sliding back while the mould is under pressure, two brass-headed pins are riveted in the pin side of the mould between the bicuspid and molar block, as shown in Fig. 289, the pin being partly in the mould and partly in the crown-pieces.

The cutting and smoothing of the gums and faces of the teeth in the castings is not, as is generally believed, a very difficult mechanical ope-

ration; it does, however, require artistic skill and judgment. The fine lines of the plaster pattern are made less distinct by the casting of the metal. The gravers are to be employed to restore the definiteness of outline and contour, and great care must be taken in doing this to avoid change or obliteration of the characteristic features of the original pattern. The gravers should be of the best quality of steel tempered to a straw color; they must be kept ground to a long bevel and a keen edge, the latter being made by means of an Arkansas stone: the gouge-shaped graver is used at first to cut a clean and smooth surface on the part of the mould representing the faces of the front teeth. A plaster set of teeth should then be made, which, on comparison with the original patterns, will indicate that further cutting is needed to bring the mould to correspond exactly with them. The pin side of the mould will require trimming with the flat or chisel-shaped graver to give it a smooth surface, and to bring the size to that of the original pattern, which should fit perfectly into the brass mould as though it had been moulded there; and this is a good test for the accuracy of the brass casting.

During the cutting repeated trials should be made with plaster to see if the edges come properly together with no overlapping; and as the cutting proceeds it will be necessary for the workman to frequently see the reverse aspect of the teeth: this he does with black try-wax, which is made by mixing beeswax and lampblack with a few drops of turpentine. Small pieces of this wax are held in the hand while cutting, the warmth of the hand being sufficient to soften it: in this way the mould-maker is able to take impressions of the concavities of the teeth as the work proceeds. Care is required in carving the original patterns to form the margins around the necks of the teeth, so that they are sharp and sufficiently well defined to keep the gum enamel from mixing with the crown enamel when the mould is pressed. The mould-trimmer must be cautioned against obliterating this line of demarkation between crowns and gum.

The finishing of the pin side of the mould is a purely mechanical operation, and is done with square-edged gravers of several different sizes. In finishing corners and levelling straight edges a small variety of square-edged punches can be used to advantage.

When the mould is complete in respect to size and form of the teeth, another set of plaster blocks should be made in it, for the purpose of determining whether the blocks leave the mould readily when slightly tapped with a wooden mallet. If the blocks are difficult to remove, it will be evident that retaining points exist which retard their delivery: these are easily discovered by the abrasion they make upon the plaster, and such points should be bevelled sufficiently to allow the blocks to drop from the mould without injury when gently tapped by the mallet on its sides or ends. Finally, small holes are to be drilled in the pin side of mould for the platinum pins; these holes are drilled perpendicularly to the face of the mould and parallel with each other, five for each front block, four for the bicuspid blocks, and three for the molar blocks. The mould is now to be thoroughly cleansed of all particles of brass, and is ready for use.

Moulding and Burning Block Teeth.—The first step in moulding is to oil the brass mould and put the platinum pins in the small holes drilled for their reception in the pin side of the moulds. The point

enamel is then put in the face side of the mould, and arranged with a small spatula to the full thickness at the point and tapered down sparingly toward the neck. A thin coat of point enamel is placed on the lingual side of the front teeth and on the masticating surfaces of the bicuspids and molars. The mould is then laid aside to dry before placing the gum enamel in place. Some makers of teeth use but one enamel: instead of applying a yellow neck enamel, they allow the body to show at the neck of the tooth; this is probably done to save time and labor, but it does not afford the best results as to translucency and natural appearance.

The gum enamel is mixed with water and made just stiff enough to stay where it is placed by the enamel spatula, and is then spread evenly over the gum surface of the mould, the thickness being ascertained by touching the point of the spatula to the mould at every eighth of an inch. The placing of the enamel requires more experience than does any other part of the moulding process. The gum enamel must be placed close to the necks of the teeth, but must not be allowed to impinge upon the crowns: when complete it is allowed to dry partially.

The body is applied in small pieces slightly in excess of the quantity needed for each block. These are taken up with a small spatula, formed into balls, and laid on the pins in the pin side of the mould. The two sides of the mould are then placed quickly together, put under the press, and the lever applied to force the two parts of the mould together. The mould is then taken from the press, put in an iron clamp, and screwed firmly together: it is then heated on a stove until the mould becomes hissing hot, when it is taken off and allowed to cool sufficiently to handle. The clamp is then removed, the mould opened, and the block made to drop out by striking the mould with a wooden mallet.

If the heating has been carried to the proper point, the blocks will be found hard enough through the agency of the starch—which, it will be remembered, is an ingredient in the formulas for bodies for moulded teeth—to admit of trimming: this is done with small files and separating saws. After trimming, the blocks are laid aside in complete sets for burning.

Moulds for Special Cases.—Moulds of blocks for special cases can be made by any dentist who is willing to give his time and labor in the production of highly artistic imitations of the natural organs Fig. 293 shows models made by the author for such a special case. The patient, a lady of thirty-two, had lost all the superior teeth in consequence of extensive exostosis of the roots. The incisors and cuspids had been preserved by the patient, and served as valuable guides in the preparation of the brass mould. The bite was an exceedingly short one, as shown by Fig. 292, yet considerable fulness was required to restore the natural expression of the lip. A gold plate was made to the model, the roots of the natural teeth were cut off, and the crowns fitted to the gold plate just as ordinary plain teeth would be. Calculating the total shrinkage as one-sixth the bulk of the teeth, allowance was made by spaces left between the natural teeth (Fig. 293). The gums were formed of wax and modelled to imitate the irregularities of nature as closely as possible; plaster walls were then made in the manner described on page 243. These walls, which served as impressions of the natural teeth, were removed when the plaster had become sufficiently hard, and given two

coats of shellac varnish and then oiled. The plate was thoroughly cleaned of adhering wax, the walls were replaced, and plaster was run in between inside and outside walls, as described on page 243. By this means plaster facsimiles of the natural teeth, which had been temporarily set upon the plate, were obtained. The spaces which had been left were then filled up with plaster mixed with water and applied with a camel's-hair brush until the width and length of each tooth were increased one-sixth, and the outline and contour of the natural teeth closely imitated:

Fig. 292.

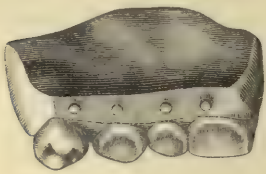
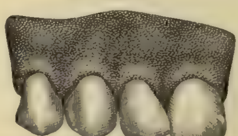


Fig. 293.

this, of course, required careful modelling with the natural teeth for guides. To save time, two blocks of four teeth each were made, including the central and lateral incisors, the cuspids and the first bicuspids, the second bicuspids and molars, were selected from ordinary stock teeth. Fig. 293 shows the arrangement of teeth with the spaces; the dotted line indicates the additions made to the width and length to compensate for shrinkage. Fig. 294 shows the block enlarged and modelled to imitate

Fig. 294.

Fig. 295.



the natural teeth and gums. A plaster mould was made from the two plaster blocks of four teeth each; this was reproduced in hard brass, the trimming and adjusting of which was carefully done, so that no change would be made in the outline or contour of the faces of the teeth. The mould with sample of shade was then sent to a manufacturer to have several pairs of blocks made. Fig. 295 illustrates the block after burning: comparison with Fig. 294 will show the difference in size between the unburned and burned blocks.

All-porcelain Dentures.

Under this heading are included full and partial dentures made entirely of porcelain in one continuous piece. The most favorable cases for this form of denture are those in which the natural gums are very much absorbed, resulting in a very flat palatine arch. In such cases there is generally room for sufficient body to afford reasonable strength. The following is the method given by Dr. Wm. R. Hall in carving full upper sets:

Two casts are taken from a plaster impression of the edentulous upper jaw. A thin lead plate is then made to fit one of the casts by burnishing it down in every part. A piece of softened beeswax is then put on the ridge, and the articulation procured in the usual way: extra care must be taken to trim the wax to the exact fulness and height required. The cast and wax articulating model must then be enlarged to compensate for the contraction of the porcelain in burning: this contraction amounts, practically, to one-ninth of its bulk.

To make this enlargement the cast and articulation are divided with a thin saw into four sections. The first line of division is at the centre along the mesial line to the back of the cast; the second, across the cast just back of where the cuspid teeth are located. The wax articulation can be cut freely with a piece of fine wire.

Previous to this division the bottom of the cast must be made smooth and level: this is most easily done by pouring mixed plaster on a piece of window-glass and setting the cast on it, letting it remain until the plaster sets hard, then trimming the edges.

After the cast has been divided the sections are again placed on the piece of glass in such a manner as to leave between each of them a space of about a quarter of an inch: if in irregular cases more accuracy is desired, the proportional dividers should be used. The space must then be filled with freshly-mixed plaster, the sections being held in position by small pieces of wax. When the plaster becomes firm a new lead plate is cut, and by burnishing is made to fit accurately. The sections of the wax articulating model are placed on the enlarged cast, and the interspaces are filled with melted wax, thus making the model conform to the size of the enlarged cast.

An outside wall must then be made for moulding the body: this is done by bending a piece of tin round the front and sides of the cast (with the wax articulating model on it) to get the correct curve. The tin is then removed one-fourth of an inch from the cast in front and at the sides, and is sustained in this position until freshly-mixed plaster is poured into the space between the cast and tin. When this wall is trimmed it should reach one-fourth of an inch above the articulating wax, after the removal of which the wall should be lined with tin-foil. Both the cast and the wall are then freed from all small pieces of wax or plaster and perfectly cleansed for moulding.

The body is prepared as directed in the section on block-carving, and is moulded on the lead plate made to fit the enlarged cast: the lead plate is used to facilitate the removal of the moulded set from the cast. The lead plate and inside of the wall should be oiled, and a piece of the body large enough for the purpose laid on the lead plate before the wall is put in place, and gently worked over the edge of the gum with the fore finger until it reaches the proper limit of the plate line. The wall is then put in place, and held firmly while the body is packed up against it as high as the top of the wall: the rest of the body is then pressed down to the surface of the lead plate, extending back as far as it is proposed to carry the plate. The body is then allowed to dry sufficiently to carve into shape. The wall is removed and the moulded set examined: if the body has split in drying, it can be repaired by working water into the fissure with a small carving knife. The moulded

piece should then be carved out roughly on the cast in the manner directed in the section on block-carving. When roughly carved and reduced to nearly the proper thickness, the piece must be thoroughly dried and biscuit-baked in the furnace : all errors in the carving are then corrected. When the piece has been enamelled and the final carving and gumming completed, the set is dried, and is then ready for the muffle.

The burning of such large pieces of porcelain is more difficult than the burning of ordinary blocks : it is not admissible to draw the slide to the mouth of the muffle and return it again if not quite fully glazed, as this might crack the set. To determine the proper degree of glazing, small pieces of body with enamel on them are placed close to the set on the side near the mouth of the muffle : these may be pulled out with a hooked iron rod and examined. When removed from the furnace to the cooling muffle, the set should not be allowed to remain in the open air a moment longer than is necessary to carry it thither. The muffle must be immediately closed with a hot stopper from the furnace. The extra precaution is sometimes taken of covering the muffle with hot ashes to retard the cooling process.

The requisite care in adjusting the set on the slide for burning must not be omitted : the sagging of the palatine arch is of frequent occurrence if it is not properly supported. If the whole weight of the piece should rest on two or three points of the gum, it might result in serious warping. To provide against such a result, *clay supports* are moulded, upon which the piece of carved work rests and is sustained during the burning process. The formula for the composition of the support is—

Kaolin or white clay,	1 part ;
Pulverized quartz,	2 parts.

Mix with sufficient water to form a mass plastic enough to mould in small pieces to the under side of the carved set.

Four small pieces made into balls are required—three in the groove directly under the teeth, the fourth under the palatine portion of the set. These balls are placed on a piece of glass in position for the teeth to be pressed firmly down on them, and are left undisturbed until the supports are dry enough to be safely removed. They are then to be surfaced with powdered quartz, and dried to be ready for use.

When the teeth are removed from the cooling muffle the set will require more or less grinding to fit the original cast, which, as will be remembered, was left unenlarged. This is accomplished with corundum wheels and points. To facilitate the grinding the prominent parts of the cast are coated with a mixture of rouge and oil, which will spot the under side of the set and show the exact place to be ground off to make the case fit solidly on the cast.

Very small corundum wheels and points are needed for grinding the more inaccessible places and for making small depressions for the rugæ, etc. : these wheels and points should be mounted on long thin mandrels, and be held either in the hand-piece of a dental engine or in a chuck attached to the grinding lathe.

With these appliances the successful result will depend upon the skill and judgment of the operator.

Burning.—In manufacturing on a large scale the blocks are arranged in complete sets on a fire-clay slide covered with coarse quartz. These slides are $6\frac{1}{2}$ inches in width by $9\frac{1}{2}$ inches in length: they have raised edges to retain the quartz which serves as a bed for the blocks; they hold from twelve to fifteen sets according to the size of the blocks.

The furnaces used by the large manufacturers, having a capacity of three or four hundred sets per day for one furnace, are built of ordinary red brick held together with iron bars, the inside being made of fire-brick. These furnaces are square, with a heating oven directly over the fire, the muffle being placed lower down: the furnace is connected with the smokestack by flues at the top. The muffles are constructed of the best prepared fire-clay, 27 inches long, 8 inches wide, $5\frac{3}{4}$ inches high, and $1\frac{1}{4}$ inches thick. The muffle must be thoroughly swabbed with clay mixed thin with water, to fill up all cracks or defects through which the gases from the fuel might enter the muffle. Such accidents are of frequent occurrence in burning, and are always ruinous to the teeth, the gas generally imparting to them a ghastly blue appearance.

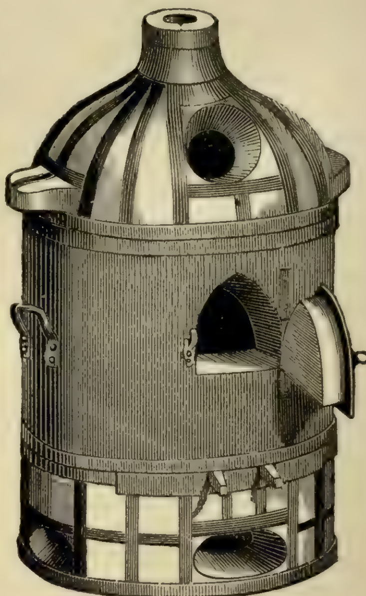
As it is necessary to cool the blocks very gradually after burning to prevent cracking, they are placed in cooling muffles or ovens made of flat pieces of fire-brick about 12 inches square. These are built in tiers of ten in each row: each oven is provided with a loose fire-brick stopper.

Large furnaces of this description require a charge of nearly half a ton each of the best grade of anthracite coal. The slide containing the teeth is placed in the heating muffle at the top of the furnace before burning: this preliminary heating prepares them for the higher temperature of the muffle, into which they are lifted on a flat iron shovel; the door is then closed. The length of time required for burning the blocks on each slide varies according to the heat of the muffle: about fifteen minutes is allowed each slide, and the draft is regulated by dampers arranged on the top of the smokestack, operated from the inside of the furnace-room. When the teeth glaze in less than fifteen minutes, the damper should be closed enough to diminish the draft. A too rapid heat tends to burn out or vaporize the colors of the enamels. The proper glazing of the teeth is ascertained by placing them under a gas-jet, and when the final burning is satisfactorily accomplished they are put in the cooling muffle, protected from the air by a door or stopper, and left undisturbed until quite cold.

Furnaces, Muffles, Slides.—These are made of *burnt clay* pounded into a coarse powder and mixed with fresh clay in proper proportions to form a plastic mass for moulding. This combination of burnt and unburned clay is made to lessen the shrinkage which occurs in all clays when exposed to high temperatures. After being kiln-burned the muffles will always be found to be somewhat porous, and, unless the pores are filled up with kaolin mixed with water and well rubbed in with a sponge inside and outside, gases from the fuel will get through and discolor the teeth. The muffle of the furnace should receive a thorough swabbing with fire-clay or kaolin after every heating.

The furnace generally used in burning carved block work is shown in Fig. 296. It is oval in shape: the muffle, occupying the shortest diameter, leaves sufficient room inside for the fuel. The height from the top, exclusive of the pipe extension to the bottom, is 32 inches. The furnace is in three sections, the muffle being fixed in the middle piece, which is 15 inches high; the dome, or top piece, is 8 inches high; the ash-pit, or lower piece, holding the iron bars which serve as a grate, is 9 inches high. The width or largest diameter of the middle pieces is 18 inches. The other sections correspond in width with the middle piece. The muffle is $3\frac{1}{2}$ inches, inside measurement. This part of the furnace requires constant care and attention, as frequent exposure to very high temperatures causes sagging and partial collapse of the sides, by which its width may be diminished: for this reason the slide should not measure more than $2\frac{1}{2}$ inches in width. This is sufficient to hold eight carved blocks without danger of contact with each other. The door of the muffle is attached to the sheet-iron jacket of the furnace by a hinge, and when closed is securely held by a thumb-latch. All the parts of the furnace are bound or covered with sheet iron, as seen in the illustration.

FIG. 296.



One charge of coke will burn but one slide of carved blocks. If the coke is well packed, the burning heat will last for half an hour. The combustion of coke is very rapid, and no time is to be lost in taking advantage of the proper degree of heat for burning while it lasts. The fire is made with small pieces of kindling-wood laid upon the iron bars under the muffle: these are lighted, and sufficient coke, not of too large size, is shovelled in until even with the top of muffle: the stopper is then placed in the dome section of the furnace, and when the coke is ignited and the lower part of the muffle is slightly red hot, the draft is removed. All the ashes of the kindling-wood are carefully raked out; fresh coke is added and carefully packed under the muffle and quite up to the stopper, until there is no room for more fuel; the stopper is then placed in and luted up with clay. Anthracite coal is used in the same way: the burning temperature can be maintained by it for a much greater length of time, but the long-continued heat which it affords is objectionable, and is more or less destructive to the muffle. Two or three slides can be burned at one heating with hard coal.

When ready for burning the blocks are placed on a bed of coarse quartz of the size of scouring sand. The blocks are stood nearly upright on the gum edges, and the coarse quartz is banked up under them in a manner to thoroughly support them, so that they will not warp or twist

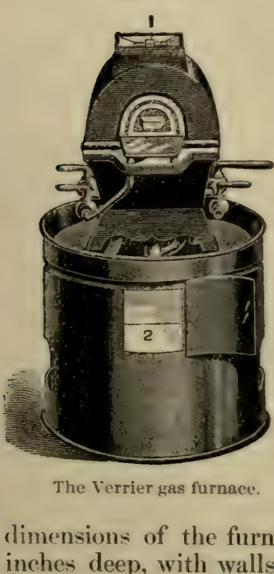
while partially fused. The quartz must not be allowed to touch the outside or enamelled part of the block. The blocks must be thoroughly dried before they go into the hot muffle. The slide is then gradually placed in the muffle by means of a pair of tongs, and, a narrow muffle-shovel held by the left hand under it to guard against breaking, it is lifted carefully to the middle of the slide without jarring. The door is left open until all vegetable matter is burned off, when it is closed, and not again opened for about ten minutes. If the temperature has reached the burning-point, the blocks will appear slightly glazed and the enamel somewhat colored: the door should then be closed for three or four minutes, the slide drawn to the mouth of the muffle and quickly examined to ascertain whether the blocks are thoroughly glazed: if not, they are to be returned, the door closed, and examined again in two or three minutes, when, if properly glazed, they are to be immediately placed in the cooling muffle and left until quite cold.

The cooling muffle is intended to protect the blocks while hot from contact with the cool air: an ordinary muffle is used for this purpose, and is closed with the red-hot stopper of the fuel-hole in the dome.

Improvements in Furnaces.

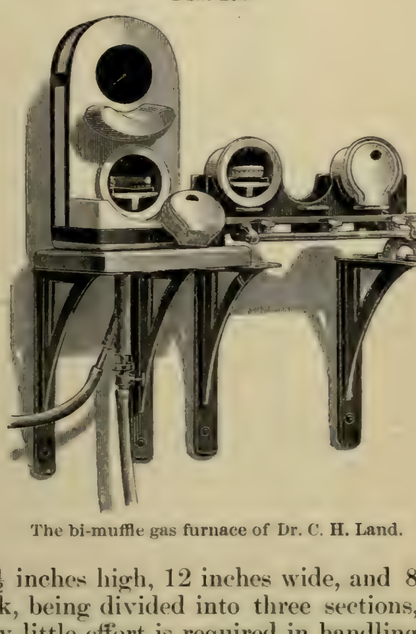
The first important modification on the old-fashioned furnace shown in Fig. 296 was made by Dr. Ambler Tees in 1880. His improvement consists in the great reduction of size of the apparatus, and in the quickness with which it can be made to do its work. It was intended principally for use in the continuous-gum process, but may be employed in burning blocks, single teeth, porcelain crowns and inlays, etc. The

Fig. 297.



The Verrier gas furnace.

Fig. 298.



The bi-muffle gas furnace of Dr. C. H. Land.

dimensions of the furnace are—15½ inches high, 12 inches wide, and 8 inches deep, with walls 1 inch thick, being divided into three sections, which so reduces its weight that very little effort is required in handling

it. Scarcely more than half a peck of coke is necessary for each burning, and when the draft is good the body of a continuous-gum denture can be fused in about thirty-five minutes after the fire is lighted: at other times, when the draft is not particularly strong, the burning can be accomplished in about fifty minutes. An illustration of this furnace, with directions for its charging and management, will be found on page 457 (chapter on the Continuous-gum Process).

Within the past few years much attention has been given to the construction of furnaces which can be operated successfully without the use of solid fuels: this has been accomplished in the use of gas in combination with the air-blast. Dr. C. H. Land of Detroit, Michigan, has invented four different forms and several styles of gas furnaces for the fusing of porcelains and melting of metals, which are said to be much more economical, cleaner, and have made the fusing of porcelain safer and more certain in results than is possible with coal or coke.

The successful application of these later devices gave promise of greater economy of time in firing, freedom from dirt, smoke, and prolonged heat after the work was done—the greatest objections to the old-fashioned solid-fuel furnaces. The liability to the vexatious accident of "gasing," however, still remained; but in later improvements this objection has, it is believed, been entirely overcome. In the bi-muffle gas furnace of Dr. Land it is claimed that high-grade porcelain can be fused in from six to fifteen minutes: it has been found very useful in changing the forms or color of plain teeth, in porcelain crown- and bridge-work, in adding any style of platinum pins or loops to suit special cases, making sections of block work, changing plain teeth into gum teeth, and making porcelain inlays, etc.

The Verrier gas furnace is an invention of Dr. A. B. Verrier of Weymouth, England (Fig. 297). It is operated by coal gas or benzoline vapor in conjunction with the blast from the foot-bellows. Its dimensions are 6 cubic inches, and it is so small that it may be placed upon a bracket in the workroom. The inventor claims that within ten minutes from the time of starting the fire sufficient heat will be obtained to fuse the body and gum enamel.

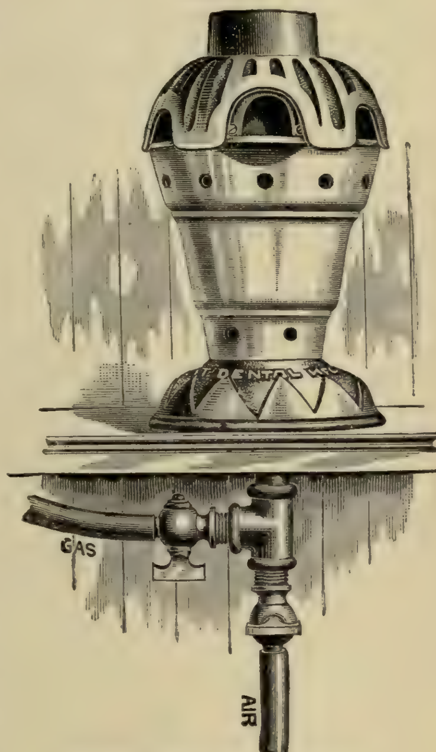
The Downie Furnace.—This furnace is designed for baking crowns, porcelain inlays, sections, etc., and is undoubtedly an improvement on any gas furnace which has preceded it. The muffle is made of platinum, thus entirely obviating the danger of "gasing" which is so liable to happen in the porous fire-clay muffle. It does its work so quickly that porcelain inlays can be fused in about one minute and crowns in from two to three minutes from the time the furnace is lighted. The size of the muffle is $\frac{7}{8}$ of an inch wide by $\frac{3}{4}$ of an inch high. The openings at the sides of the entrance to the muffle are temporary ovens in which to set the work to gradually cool after baking. The operator can easily see the work while baking, and readily distinguish when the fusing of the porcelain is complete. With it broken teeth may be repaired, and crowns and porcelain teeth may be built to any shape desired.

A small platinum tray takes the place of a slide: the crown inlay or tooth is placed upon it and carried into the muffle (Fig. 299).

To Make the Downie Crown.—Take a strip of platinum of sufficient width for the band. Cut the band a thirty-second of an inch longer than

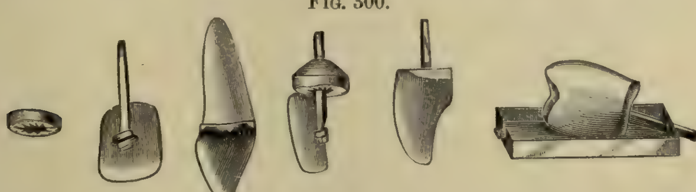
the circumference of the root; level both ends before lapping them and solder with pure gold. Fit the band to the root, letting it extend slightly under the free margin of the gum and down beyond the surface of the root about as much as it extends above. Remove the band and clip out V-shaped cuts all around. When the band is replaced in position the points are to be bent down upon and over the root. The band will then appear as in Fig. 300, *a*. Select a plate tooth, take a square iridio-platinum wire of sufficient size for the post, taper one end, and flatten the other with a hammer a little wider than the space between the pins of the tooth; file a notch in each side, and, placing it between the platinum pins, bend them over as in Fig. 300, *b*, and solder with pure gold. If the bite is close, grind the pins down to give room. After fitting the tooth to position by bending the post, if necessary, or grinding the base of the tooth, put a napkin in the mouth, dry the root and adjacent parts, and, warming a small pellet of sticky wax, place it on the end of the root and force the post through it and the tooth to its proper relation to the root. Press the wax up against the back of the tooth and ascertain whether the articulation is correct. Fig. 300, *c*, shows the tooth set on the root with wax backing. Carefully remove it by loosening the band with a hoe-shaped excavator. Remove the wax from around the post where it has been forced into the canal. Mix silex and plaster in the proportion of 2 parts of plaster to 3 parts of silex, and fill the band with the investment, building up slightly around the post: after the investment sets boil out the wax.

FIG. 299.



Downie's porcelain crown furnace.

FIG. 300.



a *b* *c* *d* *e* *f*

Fig. 300, *d*, shows the tooth with the investment in the band and the wax removed. The porcelain body is now built on until the tooth corresponds in shape to the natural teeth, when it is put in the furnace and fused. More body is then added and the band covered so as to conceal it: the crown is then fused a second time, when it may be considered as finished, as seen in Fig. 300, *e*.

In baking the crown is placed on the platinum tray, as shown in Fig. 300, *f*, putting the post through the hole in the back end of the tray, face up. This prevents the tooth being fused fast to the tray.

Ordinary teeth for vulcanite work answer well in making this crown. When they are used the post should be soldered between the pins with pure gold.

In the case of bicuspids and molars, especially where the bite is short, it is often better to build them up entirely with the body and not use any tooth or facing. The author has frequently secured satisfactory results in the case of bicuspids and molars by making a cap of platinum and then enamelling it with a body which corresponds in color with the natural teeth.

The Downie Furnace for Bridge-work.—This is of larger size and greater capacity than the preceding, and is designed especially for bridge-work, gum sections, etc. It has a platinum muffle $1\frac{3}{8}$ inches wide and 1 inch high. Crowns and bridges can be fused in this furnace in from two to four minutes from the time the furnace is lighted, although, for the greater safety of the teeth, it is better to light the gas and allow it to burn for a few minutes without the blast. The opening of the muffle is not closed while the crown or bridge is being enamelled, and the work may be watched constantly until the proper point of glazing is reached. The temperature falls the instant the gas is extinguished: the crown or bridge may therefore be left in the muffle until it is entirely cold.

Porcelain bridge-work has many advantages, amongst which may be mentioned cleanliness and the complete concealment of the metal frame-work. Wherever a cap or ferule is visible, it is only necessary to extend the porcelain coating to it and it appears as a continuation of the tooth.

The Downie Furnace for Continuous-gum Work.—This is a similar furnace, made large enough to receive a full upper or lower denture. Like the two preceding ones, the muffle is formed of platinum, and all liability to cracking of the muffle and the consequent gasing of the work, so frequent where fire-clay muffles are used, is entirely done away with. After a short preliminary heating without the blast to prevent fracture of any of the teeth, the case may fused in about twenty minutes from the time the furnace is lighted, the front of the muffle being open, so that the proper degree of fusion is easily seen the instant it is reached.

Tempering ovens are arranged on each side of the opening into the muffle, and the hearth is provided with two slides, so that the case can be brought out on to the hearth and put into the tempering oven by simply shoving the slide to one side by the small porcelain knob seen at the bottom of the hearth.

The fuel used with the Downie furnace is either ordinary illuminating gas or gas generated from gasoline, the latter being quite as effective as coal gas, and much cheaper. An apparatus has been designed

for use with the Downie furnace, which it is claimed generates gas at a cost of about ten cents per one thousand feet. This gives dentists practising in small towns the same advantage as those in cities, as it will operate either of the furnaces above described equally as well as coal gas.

Fig. 301 illustrates the foot-bellows used for supplying the air-blast: it is made in three sizes to correspond with the capacity of each furnace. These bellows have improved rubber treadle feet to keep them from shifting when in use, and nets made of strong flax cord. Their dimensions are as follows:

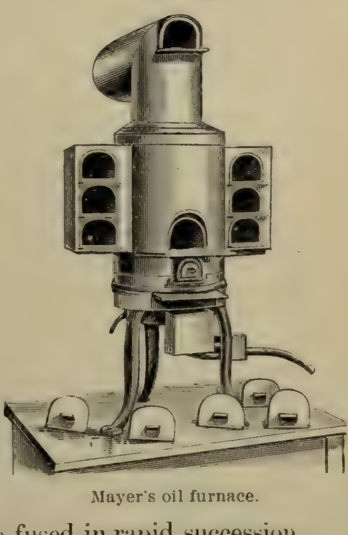
Small, $8\frac{1}{4}$ by $9\frac{1}{2}$ inches.
Medium, 10 by $11\frac{1}{4}$ "
Large, 12 by 13 "

Fig. 301.

Foot-bellows for the Downie furnaces.

Dr. John H. Mayer describes a preparatory muffle and annealing ovens to be used with an oil furnace for continuous-gum and other porcelain work. The preparatory muffle (Fig. 302) is placed in the elbow of the furnace-pipe, and so arranged as to utilize the escaping heat as it passes upward from the furnace. The heat distributed around the muffle reaches a temperature of about 1800° F. This preparatory muffle is large enough to receive five cases, which can be placed in it before the oil is ignited, and gradually heated up, and when the lower muffle has attained the necessary baking heat the cases may one by one be transferred to it, and when satisfactorily fused placed in the asbestos-lined ovens (Fig. 302).

Fig. 302.



Mayer's oil furnace.

The improvement claimed for this furnace is that in ordinary single-muffle furnaces but one case at a time can receive attention, while by the preparatory-muffle arrangement five cases may be fused in rapid succession.

Electric Heat in Prosthetic Dentistry.

Dr. Levitt E. Custer has constructed a small electric oven for fusing porcelain, the heating principle of which is a coil of iridio-platinum wire imbedded in a refractory mixture just deep enough to be supported while highly heated, and yet to radiate its heat directly into the oven-cavity. This latter furnace consists of an upper and lower section somewhat the shape of the flasks used in rubber work, with an inner cavity large enough to contain an upper or lower denture of the maximum size, and with such arrangement of the wire that all parts receive the same degree of heat. (See chapter on Continuous-gum Work.) The upper half is hinged to the lower. The electric connection is automatically made by closing the sections of the furnace. There are two openings through which the fusing process may be watched. These are placed at such positions that rays of light entering one will be reflected out by the plate through the other. This overcomes the intense glare of the heat, and at the same time brings the plate clearly into view, making it possible for the operator to accurately determine the degree of fusion.

There are many possible advantages offered by the use of electricity in fusing porcelain. It gives rise to no products of combustion, and it is therefore impossible to produce with it the condition known as "gasing," and it has been observed that porcelain fused by it not only possesses unusual clearness, but appears to be more dense. The accuracy with which electric heat can be regulated by means of the rheostat, the cleanliness, simplicity, and freedom from noise and odor, are advantages over the older methods of burning porcelain work.

Electricity is so easily controlled that it is not improbable that an automatic appliance will soon be invented to regulate the heat according to the fusibility of the porcelain treated.

The best current with which to operate the Custer furnace is the Edison, but the 52-volt alternating current, while somewhat slower, serves the purpose very well.

The procedure in the practical use of the oven is exceedingly simple. The case is placed on the tray in the lower section, and the upper is then closed down. The lever of the rheostat is placed on the first button, and heat for drying out the case is quickly obtained. When the operator is satisfied that there is no more moisture present he raises the heat by pushing the lever to the right. (See chapter on Continuous-gum Work.) If he allows two minutes to each button, it will require from twenty to twenty-five minutes to reach the fusing-point. If it is a crown or bridge, less time may be consumed in raising the heat without danger to the case, and it may be fused in from ten to fifteen minutes by throwing the lever over more rapidly. When the desired temperature has been obtained and the fusing of the porcelain is complete, the lever of the rheostat is thrown back and the current cut off. At that instant the heat begins to go down, so that neither over-fusing nor loss of brilliancy in the gum color can occur.

To Fuse Platinum.—Disconnect the rheostat and attach an arc-light carbon to one wire and a carbon-battery plate to the other. Place the platinum upon the carbon plate and touch the platinum with the pencil. Upon raising the pencil an arc will be formed upon the platinum, which

will then be melted. If there is any noise in the arc, reverse the connections of the wires to the plate and pencil.

There can be scarcely a doubt that electricity will be made to meet all the requirements of the prosthetic dentist in the fusing of porcelain as well as in the melting of metals, and the electric oven of Dr. Custer may even now be truly said to be in advance of any of the older means of obtaining high temperatures.

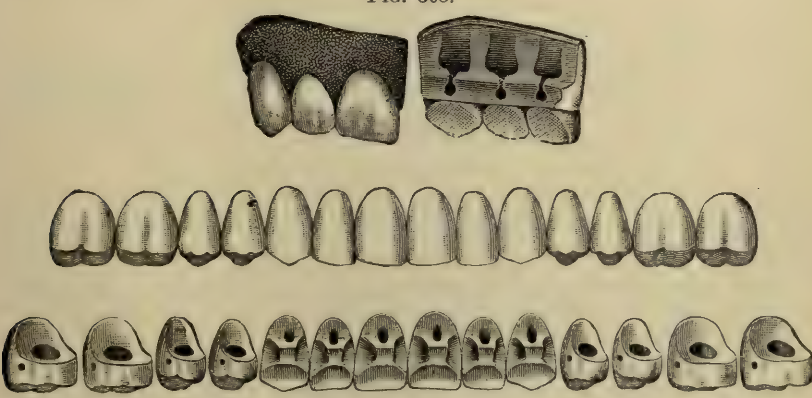
English Tube Teeth.

These are of the class of single plain teeth. They are made with a platinum tube burned in the porcelain, extending entirely through the centre of the tooth, corresponding to its long axis. In form these teeth are excellent imitations of the natural organs. The texture of the material of which they are made resembles very closely that of the natural teeth. The shape of an English tooth may be altered by grinding with the corundum wheel, and the ground surface may be completely restored to the original condition by polishing. On account of the closeness of texture and greater strength of the porcelain of which English teeth are made many expert bridge-workers prefer them to those of American make. (For full details in the setting of tube teeth, with their application to crowns and bridges, the reader is referred to the chapter on English Tube Teeth.)

Pinless Gum and Plain Teeth.

Owing to the increased demand and consequent advance in the price of platinum incident to its uses in electric lighting, manufacturers have endeavored to dispense with pins in all classes of teeth designed for rubber work. The illustrations represent a new form of pinless teeth. In these the holes are so constructed that the rubber vulcanizes well in the teeth and unites them firmly to the plate, and it is claimed that they hold equally as well as, if not better than, pin teeth.

Fig. 303.



Single Plain Teeth with Countersunk Pin.—The countersunk tooth crowns were introduced by the S. S. White Dental Manufacturing

Co. in 1885. It has been said of them that, properly mounted, they form dentures which fairly rival continuous-gum work in naturalness of appearance, without the objectionable weight of the latter. Their close conformity in contour to the natural organs makes them much more acceptable to the tongue than teeth backed in the ordinary manner, renders articulation easier and more distinct, and prevents disclosure of artificiality when the mouth is opened. In addition, it is claimed that these crowns allow of greater facility of adaptation to the maxillary ridge, and that the denture is in no degree inferior in strength to any that have yet been made on a plastic base.

Fig. 304.

These crowns may be used with either vulcanite, celluloid, or fusible-metal base.

For a vulcanite base the case should be flasked in the usual way, but in packing each countersink should be carefully filled with small pieces of rubber to ensure the rubber being thoroughly forced into the countersink and around the pins.

When the base is to be of celluloid, the countersinks must be first filled with small pieces of celluloid moistened with spirits of camphor, and the case well heated before bringing the two parts of the flask together.

For a fusible-metal base every precaution should be taken to expel the air from the countersinks, such as jarring the flask or tapping it with a mallet. It would probably be safer to use in pouring a conduit which would give the pressure of a column of the melted alloy: this would afford a sharper casting and be nearly certain to fill all the countersinks as well as all other deep places in the matrix.

Great improvement has been made in the variety of sizes and forms of porcelain teeth designed for use in the continuous-gum process. Generally, these teeth are supplied with but one long platinum pin, by which the teeth are soldered to the backing strip. While the single pin is probably sufficient for strength, it is often found to be inadequate as a means of holding the teeth securely in position while the denture is

being burned. To prevent lateral movement of the teeth, and to maintain their correct relation to each other, Dr. C. H. Land has recommended the arrangement of two lateral pins to each tooth, as shown in Figs. 305 and 306.

FIG. 305.

FIG. 306.

The cut (Fig. 307) shows the approximal, labial, and lingual faces of a superior continuous-gum central, the side view giving the position and length of pin and the inclination of the labial face. Fig. 308 shows the half of a set of six front teeth for continuous-gum work.

In burning single plain teeth it has been observed that exceedingly small specimens vitrefy more quickly and are more liable to change of

FIG. 307.

FIG. 308.

form from over-burning than the larger ones. To avoid accidents of this nature it has been recommended that the small be separated from the larger teeth, and that each lot be placed upon the slide and burned separately.

FIG. 309.

FIG. 310.

FIG. 311.

Figs. 309–314, show some of the unusual forms of moulded sectional rubber blocks, in which considerable improvement has been

made within a few years. These are made in a variety of sizes and degrees of curve.

Fig. 312.

Fig. 313.

Fig. 314.

Tinting and Staining Porcelain Teeth.

Changes may be made in the color or shades of teeth, or devitalized and discolored teeth may be imitated, by the system demonstrated by Dr. George Cunningham at the Columbian Dental Congress, which consisted in the application of a set of paste colors or the stains prepared and furnished by Poulson of Dresden or Ash Sons of London.[1]

The colors usually employed in china painting will answer very well for the purpose, and a small selection, consisting of sepia, ivory black, rose pompadour (gum color), ivory yellow, brown yellow, celestial blue, and relief white will be sufficient with which to form almost any shade required in the imitations of the usual discolorations of the teeth as met with in the natural organs.

The implements required for the mixing and application of the tints are a plain glass slab, on which to mix the colors in small quantities; a small palette knife; a small, short-bristled brush for stippling or spreading the color, such as can readily be formed by cutting off the bristles of a camel's-hair or sable brush, so that the remainder is short, stubby, and square at its end; alcohol, with which to clean the teeth; brushes; oil of cloves, oil of lavender, or turpentine to thin the paints to proper consistence.

The grays, yellows, and browns are the tints most frequently required in imitating the discolorations of the natural teeth. Ivory black is of course not to be used by itself, but it is indispensable as a means of deepening the color of the grays and browns.

In the use and application of pigments for the purpose of staining porcelain teeth the operator should study the colors of the natural organs as met with in the mouths of patients, and he should acquire experience in noting the effect of admixture of the pigments when applied to porcelain teeth. This is essential, as the colors when developed by exposure to high temperatures are not always of the degree and shade expected. A few experiments, which can easily be made upon odd teeth by means of the Downie or Custer furnace, will enable the operator to apply the colors with some degree of certainty.

[1] From paper on "Artistic Staining of Artificial Teeth" in *Ohio Dental Journal*, by Dr. George H. Wilson of Cleveland, Ohio.

The occasions requiring tinting or staining are not numerous, and the system should be applied with taste and judgment. These occasions are found in cases where it is necessary to imitate the discoloration of a devitalized tooth; to deepen the color of the cuspids; to imitate the discoloration of the dentine left bare by the recession of the gums; to darken the dentine between the plates of enamel on the cutting edges of the teeth of elderly subjects; to imitate the opaque or white spots in the enamel of incisors or cuspids, or the yellow spots occasionally seen on the surfaces of the incisors.

In applying the stains the tooth should be thoroughly cleaned with alcohol, dried, and held by the pins with a pair of pliers: the color is mixed with oil of cloves or lavender and applied with a camel's-hair pencil, the quantity or thickness being governed by the depth of shade required.

The color is fixed by subjecting the teeth to a temperature of about 2000° F. The firing may be satisfactorily accomplished in either of the furnaces above named, or, as described by Dr. George H. Wilson, "by shaping a piece of No. 36 platinum plate so as to cover and enclose the teeth, except on one side, which is left open as a peep-hole. This miniature oven or furnace containing the teeth is placed over the Bunsen burner for about five minutes, when the flame from the blowpipe is placed against the outside of the clay slab, upon which it is held, and gradually bringing it over upon the top of the platinum," two minutes' work of the blowpipe being sufficient to vitrefy and fix the colors. "Atrophy and worn conditions are imitated by grinding and then staining." Gum colors are formed by the use of the rose pompadour, the depth of the shade being secured by varying the amount of the relief white.

CHAPTER V.

THE PREPARATION OF THE MOUTH; CHOICE OF MATERIAL AND TYPE OF DENTURE.

BY H. H. BURCHARD, M. D., D. D. S.

WHEN it is considered that artificial dentures are designed to restore the partially lost function of mastication, together with the appearance possessed by the mouth when the natural teeth were in position, it is evident that we have several important matters for consideration—the furnishing of a surface which shall afford the necessary support to the denture, the replacement of the organs of mastication, and the restoration of the facial expression.

The natural gums themselves, when in a normal condition, form dense, fibrous, elastic, and insensitive pads which may, without discomfort to the individual, be subjected to considerable pressure. If the gums become hyperæmic or inflamed, their sensitivity is increased; there is an intercellular infiltration of fluids into the submucosa; the epithelial covering becomes sodden; the structures furnish a yielding instead of a firm base for the support of a plate. It is obvious, therefore, that where a morbid condition exists its cause is to be sought out and remedied.

Morbid Conditions of the Gums.—The general condition of hyperæmia of the mouth will be found frequently associated with more or less inflammation of the pharynx and certain forms of gastric disorders, notably irritative dyspepsia. This oral condition will be commonly noted in spirit-drinkers and confirmed smokers. The first step toward its cure is to remove these exciting causes: the use of spirits is to be interdicted and the smoking lessened if not discontinued.

It is not infrequently found that the dyspepsia itself is traceable to the loss of the masticatory apparatus, the patient bolting food or presenting to the stomach masses much larger than can be perfectly digested. While in actual practice few of these conditions receive consideration at the hands of the prosthetist, it is undoubtedly advisable that they should be corrected in order to bring the oral structures to a normal condition.

In the condition due to non-mastication of food the gastric symptoms and oral disorders arising from them are usually relieved through the use, for a period, of soft foods and the internal administration of—

℞. Bismuth. subnit.,	gr. x;
Acid. carbolic.,	gr. $\frac{3}{4}$;
Sodii bicarb.,	gr. x.

M. et ft. pulv. (i).

Sig. To be taken two hours after meals.

The intestinal functions are to be regulated through the administration of mild saline aperients. Where the symptoms are those of chronic gastric catarrh and of fermentation of food-masses, discomfort during digestion, burning eructations, and occasional sharp pains which last during the slow digestion, the silver salts are efficacious. To allay the pain a sedative is indicated, but, as many of these cases are attended by constipation, opium is contraindicated and belladonna or hyoscyamus substituted.

℞.	Argenti oxidi,	gr. v;
	Ext. hyoscyami,	gr. v.

M. et ft. pil. No. x.

Sig. One pill three times a day before meals (*Bartholow*).

The mouth is to be washed periodically with some mild astringent antiseptic, such as borine, listerine.

If there are marked symptoms of stomatitis, probably the most effective mouth-lavage is a solution of potassic chlorate, gr. xv–℥j. Starchy and fatty articles of food are to be omitted from the dietary for the time being, as they undergo fermentative changes in the stomach. The local manifestations are to receive appropriate treatment.

Stomatitis itself may be due to a variety of causes; any cause, in fact, which lessens the general bodily tone may determine it. When it appears as small ulcers, these are touched with pure carbolic acid, and then usually take care of themselves. Their recurrence may be usually prevented through the internal administration of ℞. Acid. hydroch. dil., gtt. v.—S. Immediately after meals, well diluted. If the ulceration is diffused, a spray of hydrogen peroxide, followed by one of a solution of potassium chlorate, will be found efficacious. Mercurial stomatitis may be cured by the same local applications. In short, the several causes of stomatitis are to be sought out and removed.

Gingivitis or ulitis, characterized by a boggy condition of the gums, may arise from a variety of causes: those specifically demanding the aid of the dental practitioner are due to the presence of salivary calculi about the natural teeth, to extension of chronic inflammatory processes from the roots of necrosed or partially necrosed teeth, or, again, to any stage of the process known as pyorrhœa alveolaris, including under this head all of those inflammatory degenerations which lead to the gradual exfoliation of the teeth.

Scurvy is a malady so rare as to scarcely require mention in this connection.

Retention or Extraction of Natural Teeth.—When a case presents for an artificial denture, if the mouth be edentulous and the condition of the gums normal, the preliminary steps in the construction of a denture may be taken. If, as commonly found, there are present natural teeth or roots, it is to be determined, first, which of these shall be retained and which extracted. It is to be remembered that, although the general removal of isolated teeth may render more simple and easy the adaptation of an artificial denture, the latter is of decidedly less value to the patient than are natural teeth. Dr. Black[1] has found that the force a patient could exert upon artificial dentures was from one-tenth to one-

[1] *Cosmos*, 1895.

fourth that exerted by the natural teeth, the force of the former not being sufficient to crush many of the usual articles of diet. There will be seen in this a cause of the dyspepsia common among those wearing artificial dentures.

Whether to retain or extract roots or teeth will depend, first, upon the possibility of readily bringing such teeth to a condition of health. A general rule is that those containing vital pulps are to be retained. Teeth or roots in which there is evident necrosis of the pericementum are immediately removed, as they are an incurable source of inflammation in the gum-tissues. Roots which are the seat of pericemental inflammation are to receive appropriate treatment; if they do not respond, they are deemed a detriment and are extracted. If retained, they should perform service, and are to receive artificial crowns. If they are not sufficiently strong to furnish a base for an artificial crown, they are, as a rule, unfit for retention. It is not absolutely essential that uncrowned roots should be extracted, but their presence is generally a hindrance rather than an aid. Teeth of which the crowns have been lost, if brought to a condition of health, by receiving artificial crowns may be made to furnish acceptable clasp teeth.

The gums about vital teeth must be brought to a condition of health. The most common source of inflammation, deposits of calculi upon the gums and beneath the margins, must be thoroughly removed, and the gums receive such treatment as shall render them firm and resistant, the operator painting them occasionally with dilute tr. iodine, the patient to employ an astringent and antiseptic wash until a normal condition obtains. One of the most satisfactory of formulæ for this purpose will be found in a wash of—

℞. Zinc. chlorid.,	gr. v–x;
Aquæ,	℥j.—M.

Sig. Its use continued for a week.

Should the tumefaction of the gum-tissue be but slight, a mildly astringent wash suffices:

℞. Ext. hamamelis virg.,	℥j;
Aquæ,	℥vj.—M.

Sig. Used ad libitum.

The gradual and progressive loss of teeth, due to the process called pyorrhœa alveolaris, leaves the poorest of bases for an artificial denture. The gradual loss of the alveolar process which accompanies, or rather causes, the loss of the teeth leaves the condition known as the flat, flabby arch. The resorption is confined to the bony tissues, leaving the engorged soft tissues without a corresponding diminution of volume. It is needless to emphasize the extreme importance of checking and holding in check this malady, the *bête noir* of dentistry.

In examining the palatal vault it is to be noted whether its configuration is such as to militate against the employment of a chamber plate. Are there protuberances or tuberosities of bone occupying a portion of the vault to be covered by the vacuum chamber? In that event it is

doubly desirable that clasp support be obtained, and so increased significance attaches to the retention of such roots as may be properly crowned or such teeth as may serve for clasp attachment.

The question frequently arises whether or not to extract isolated teeth which are healthy, but which render more difficult the adaptation of an artificial denture. The writer advises against it as a general rule. Such teeth are valuable in that they stay the bite. In occluding they limit the amount of displacing stress brought to bear upon the artificial denture, and thus increase its actual capability of service. Such teeth are lost sooner or later, and yet they may remain for many years. It is especially desirable that the cuspid teeth be retained. They maintain a contour at the canine eminences which the artificial denture does not always fully restore when once lost. Even the roots themselves should, when possible, be retained, and crowned when practicable.

It is better, as a general rule, to retain all healthy teeth and roots: the skill of the operator is to make his work conform to conditions rather than alter conditions to suit his convenience.

A solitary tooth remaining in the upper arch necessitates a break in the general plate outline detrimental for the following reason: The gum upon which the plate rests at the site of the natural tooth undergoes absorption, and hence a space develops between plate and gum which permits the ingress of air to the palatal surface of the plate and destroys atmospheric adhesion. Isolated molars, if perfectly firm, are to be permitted to remain; even more, in many cases they are to be carefully preserved. If there be one on either side, a double advantage is obtained: if the future denture is to be mounted upon a vulcanite plate, the latter, embracing these natural teeth, has an additional source of support; if mounted upon metallic plates, these teeth furnish means of clasp attachment.

In the lower jaw teeth which stand in a column of two or more than two should nearly always be retained. Isolated teeth are to be retained when they can possibly be made to serve as clasp teeth. Lower dentures, depending almost entirely upon weight to keep them in position, need clasp support whenever admissible. Even a solitary bicuspid should usually be retained, and if one on either side can be retained the patient is immeasurably the gainer.

A solitary inferior incisor is to be extracted: the writer also advises the extraction of a superior lateral incisor when the latter is the only tooth remaining. It will not remain long enough to be of any actual service, while a central may last much longer; but even a central incisor, except under unusual circumstances, when it is the solitary tooth of an arch, had better be extracted.

Surgical Complications.—The length of time to elapse between the extraction of teeth and the insertion of artificial teeth varies with the existing conditions. After the forcible removal of a firmly implanted tooth there is more or less inflammatory swelling of the soft tissues. A plate or tooth adapted to such a place during the height of the swelling would have its relation to the gum altered as soon as the swelling has disappeared. It is the general rule, therefore, to await the subsidence of the inflammatory swelling before taking an impression. Should it be that it is imperative to insert the artificial teeth immediately

upon the extraction of the natural organs, due allowance is to be made for the inevitable swelling and subsequent shrinkage. Succeeding the latter will be a resorption of the alveolar process, which varies widely its extent according to the individual and the local conditions.

In very rare instances the following condition may be found: At some point a cicatricial adhesion has occurred between the mucosa of the cheek and that of the alveolar wall. This may be a cord-like attachment which marks the site of the fistulous opening of a previous abscess; the point of the attachment may be at any part of the alveolar wall. Unless it should be at the level with the top of the alveolar arch, it will not disturb the stability of an artificial denture and calls for no interference. Should its attachment be at or beyond the height of the ridge, operative measures are indicated, as the movements of the cheek transmitted through the cord would displace a fixture.

Wounds of this part of the mouth, whether incised or from injuries by caustics, may in healing cause extensive attachment of the cheek to the alveolar wall, and render the wearing of a plate difficult if not impossible. The surgical principle involved in correcting the condition is a separation of the attachment and preventing adhesion of the cut surfaces until perfect cicatrization has occurred.

An impression of the mouth is taken and a model made. (See Chapters VIII. and IX.) At the site of the adhesion represented on the model the latter is cut away to the usual plate depth, leaving the model more prominent than anatomically correct, so that there shall be no pressure by a plate upon the alveolar wall. A plate of vulcanite is constructed upon the model, its edges rounded, smoothed, and the entire piece highly polished. When this is finished the mouth is thoroughly sterilized and painted with a 10 per cent. solution of cocaine; the cheek is drawn away from the alveolar wall, making the tissues tense, and a sharp bistoury is used to divide the attachment, the cut to be made in the middle of the attaching tissue. A styptic applied or a spray of hydrogen peroxide usually checks the hemorrhage. The cut surfaces are dried by means of lint, both are painted with a solution of styptic collodion, and as soon as this has dried the plate is inserted. The antiseptic varnish called steresol is an admirable covering for these as for any wounds about the mouth. The patient is directed to wash the mouth several times a day with an antiseptic such as borine, listerine, borolyptol, etc., and the case, if the person be healthy, should rapidly proceed to cure. Should the granulating surfaces become unhealthy-looking, they are to be washed or painted with a solution of silver nitrate, gr. iv–℥j. The plate is worn until healing is complete, usually in about two weeks, when an impression for a denture may be taken.

Choice of Base.—In the mouths of patients who have worn artificial dentures it will be found not infrequently that the tissues underlying the plates are in a condition of hyperæmia or even marked congestion. While this condition is more common under plates of vulcanite than under those made of metal, it is occasionally found under the latter class of plates. It is most usual under vulcanite plates which are improperly finished on the palatal surface, the roughness of the latter acting as an irritant to the soft tissues. In the degree that plates of this base are highly finished there is a lessening of what is called rubber

sore mouth. Lack of cleanliness upon the part of a patient is a prolific source of the hyperæmia. Deposits of food-débris, being permitted to remain upon the plate, undergo fermentative and putrefactive decomposition, the products of which act as irritants. Aside from vascular injection of the soft parts due to these palpable sources of irritation, instances are seen where the wearing of a vulcanite plate, no matter how carefully finished or cleansed, is attended by hyperæmia of the underlying tissues. In lieu of a better explanation this condition is ascribed to lack of conductivity of the base. This view becomes more plausible when it is seen that a plate constructed of a good conductor (of metal) may be worn without causing the effects noted under plates of vulcanite.

Vacuum chambers which are too deep and which have too sharp edges are a source of irritation. Therefore, where an artificial denture upon a vulcanite base is presented for examination, complaint being made by the patient of soreness of the parts enclosed by it an examination is made to note the position of the irritated areas. If due to the cutting of the air-chamber, the edges of the latter must be smoothed and the chamber partially obliterated by placing a thin layer of paraffin and wax in it. Should the plate be rough itself or contain foreign substances, it is washed with a strong antiseptic. The writer lays the plates in a 10 per cent. solution of sodium peroxide; they are then rinsed in a 5 per cent. solution of sulphuric acid, scrubbed, and their palatal surface brushed with pumice and stiff brushes.

Where and when a choice of base is admissible gold is as much king in prosthetic as it is in operative dentistry. A general rule for its employment, based upon the cases or classes of cases in which it is found to serve best, would be as follows: It is the only material in present use which meets all the indications for a proper base for all partial dentures.

In full cases gold or continuous gum is the choice. It may be given as a principle that the tissues of the mouth prefer the contact of a metal surface to that of one of the vegetable bases; so that in all cases where, by the experience of the patient, the weight of a perfectly fitted denture is not urged against gold or continuous gum, these latter are to be preferred. In lower cases, where weight is an advantage, this feature doubly recommends the metallic base. Vulcanite serves best in mouths having firm gum-tissues, a high vault, and where the bulk of the piece is unusually great, and in which the plate adhesion has been demonstrated to be weak. Flat mouths, with flabby tissues, bear metal better than they do vulcanite. Continuous-gum dentures serve best in what would be termed vaults of the average depth, moderately high alveolar walls, and where a greater bulk of material is required to restore lost form than can be had with gold plates. When accurately adapted, continuous-gum dentures serve admirably as full lower cases.

Use of Clasps.—The question of the use of clasps is determined by necessity. They are, as a general rule, attached to all partial lower dentures where practicable. When an option is admissible, they are not attached to the class or varieties of teeth which are seen to be susceptible to dental caries. If sufficient stability can be secured without their use, they are not employed. This, however, necessitates that a plate shall be large enough to serve as a stable base, one which is unnecessarily large

for carrying one or two teeth, so that small plates supporting very few teeth are frequently mounted upon small plates, and have their attachment through the medium of clasps.

Type of Denture.—Where the configuration of the vault is of such form that a median vacuum chamber is inadmissible, owing to the presence of tuberosities which cover the median line of the vault, what is known as a horseshoe chamber is tested: if this prove insufficient, two distinct lateral chambers, occupying respectively areas upon the right and left lateral aspects of the plates, may used. It is in such cases that natural teeth should be preserved to serve as clasp attachments should attempts to secure adhesion by means of the chambers prove unavailing. For the same reason roots are retained which may serve as the bases for artificial crowns, to which clasps may be fitted.

Cast or swaged aluminum dentures serve best in those shapes of vault and alveolar walls in which vulcanite renders good service, and in mouths apparently irritated by the presence of a vulcanite plate may be advantageously substituted for the latter base.

In regard to the choice between bridge-work and partial plates, if the conditions present permit the ready placement of a properly designed bridge, with a probability of its permanent usefulness, it is selected; otherwise the indication for a plate denture prevails. The direct indications for a bridge are a loss of teeth between others which have sound and firmly fixed roots, and preferably those which require no mutilation to fit them to serve as abutments; little or no loss of gum-contour at the sites of the absent teeth; an articulation of a type which shall permit the placing of perfectly protected porcelain facings, which shall meet all requirements as to restoration of appearance; the spaces beneath the body of the bridge to be accessible to tooth-brushes. The introduction of removable bridge-work has eliminated many of the objections urged against this class of fixture. In addition, what are known as detachable plate-bridges remove other objections to the general class of bridge-work; but the judgment of the conservative operator still finds many cases in which partial plate dentures are the rational indication and bridge-work clearly contraindicated.

CHAPTER VI.

TAKING IMPRESSIONS OF THE MOUTH.

By H. H. Burchard, M. D., D. D. S.

Taking an impression of the mouth is an operation of such apparent simplicity as to seem to require but brief description, and yet it is one which is as rarely done well as any operation in the practice of dentistry. It is absolutely necessary for the proper adaptation of an artificial denture that this, the primary step in its construction, be accomplished with an accuracy which shall eliminate any faults of the denture traceable to an inaccurate impression.

The operation consists in securing a perfect imprint of the jaw in some soft substance which by its hardening will retain the impression made in it. The impression material is conveyed to position and confined by means of an appropriately-shaped tray.

Materials Employed.—There are two classes of impression material in general use: first, those which are softened by heat and harden in cooling; second, those made into a paste with water, the paste hardening through crystallization. The first class includes beeswax and preparations made of it, such as wax and paraffin, wax and gutta-percha; next modelling compound, a mixture of gum copal, stearin, and French chalk;[1] lastly, gutta-percha. The second class includes plaster of Paris and the various mixtures made with it as a basis.

Plaster of Paris when in a condition of paste is perfectly adaptable to any surface, no matter how irregular the latter may be, and causes no displacement of parts or alteration of their positions. When set it possesses such rigidity that its withdrawal from undercuts is impossible without fracture of the mass or yielding of the parts enclosed by it. In setting the mass expands about one five-hundredth of its volume. It is said not to expand when sodium chloride or potassium sulphate is added to the paste. (For the chemical and physical properties of plaster, its preparation and treatment, see Chapter I. page 22.)

Beeswax.—The special advantages of wax are that it is easily manipulated, is inelastic, and contracts but slightly in cooling. The disadvantages are—the pressure required to adapt it forces all the soft parts out of normal position, and renders the taking of a perfect impression of some mouths with it impossible; the tendency to distortion of its form

[1] Dr. J. W. White, "Taking Impressions of the Mouth."

in withdrawing is also a serious objection to its use. It does not give as accurate an impression as plaster, but still is preferred by some operators.

When wax is used, either a *pure* specimen should be obtained or one which has been judiciously combined with a foreign substance for a specific purpose. Commercial adulterations with tallow, resin, vegetable wax, etc. injure it, making it difficult to manage. White wax has an advantage over the yellow in that it does not draw out of shape so readily, and there is consequently less liability to have the impression distorted than with yellow wax. It takes a sharper impression than the yellow variety, but it is more difficult to bring to the required plasticity, and more force is required to obtain a correct impression unless the wax is made hot. In summer-time the additional hardness is in its favor.

Scrap wax of either variety should never be used without remelting, as it is difficult, if not impossible, to get it into a homogeneous mass.

Paraffin is frequently added to wax, and imparts to it the property of becoming plastic at a lower temperature. A small proportion improves it, especially for use in cold weather, but if in excess it causes the wax to separate into layers which are not easily reunited. It take a sharper impression than wax alone, with less liability of drawing out of form, the addition of the paraffin in proper quantity causing the composition to be harder when cold than the wax alone. A combination of wax and gutta-percha is used and highly prized by some, on account of its toughness. The objection to it is that it is sticky. It may adhere to the plaster in making a model unless previously varnished.

The other plastic materials will be described together with methods of manipulation.

Impression Trays.—Impression trays are receptacles designed to carry impression material into position in the mouth, to retain it while there, and to hold the form of the impression during and after its removal from the mouth.

Properly shaped, a tray should represent in form the particular jaw of which an impression is to be taken, to be only sufficiently larger than the jaw to have the volume of the impression material great enough to hold together in a common mass. For the majority of cases, and with any of the materials employed in impression-taking, this would require a cup to be about one-quarter inch or less larger in all respects than the parts it is to embrace.

The well-equipped laboratory should be provided with an extensive set of trays as furnished by the manufacturer to meet the needs of the majority of cases.

Figs. 315 and 316 show the class of trays designed for the taking of full upper impressions. Three sizes will usually be found to meet general requirements.

Cups especially designed for use with plaster are illustrated in Fig. 316. These cups, made of britannia metal, may be filed, cut, or bent to conform to irregularities of arch outline or palatal vault, so that the tray shall be uniformly one-quarter inch larger than the parts it is to enclose.

Figs. 317 and 318 illustrate the trays designed for the taking of full lower impressions. These frequently require alteration of form by bend-

Fig. 315.

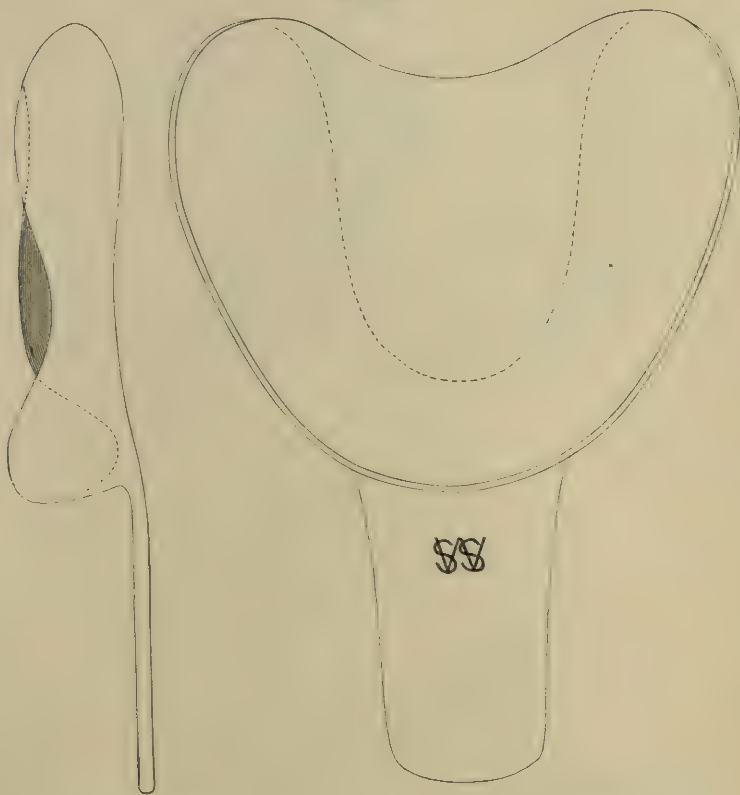


Fig. 316.

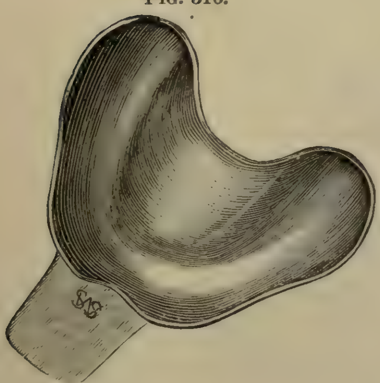
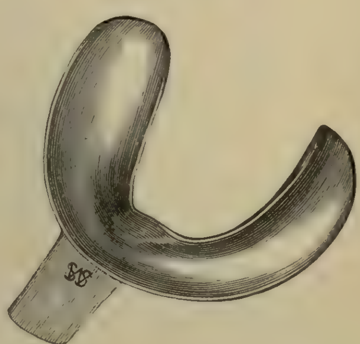


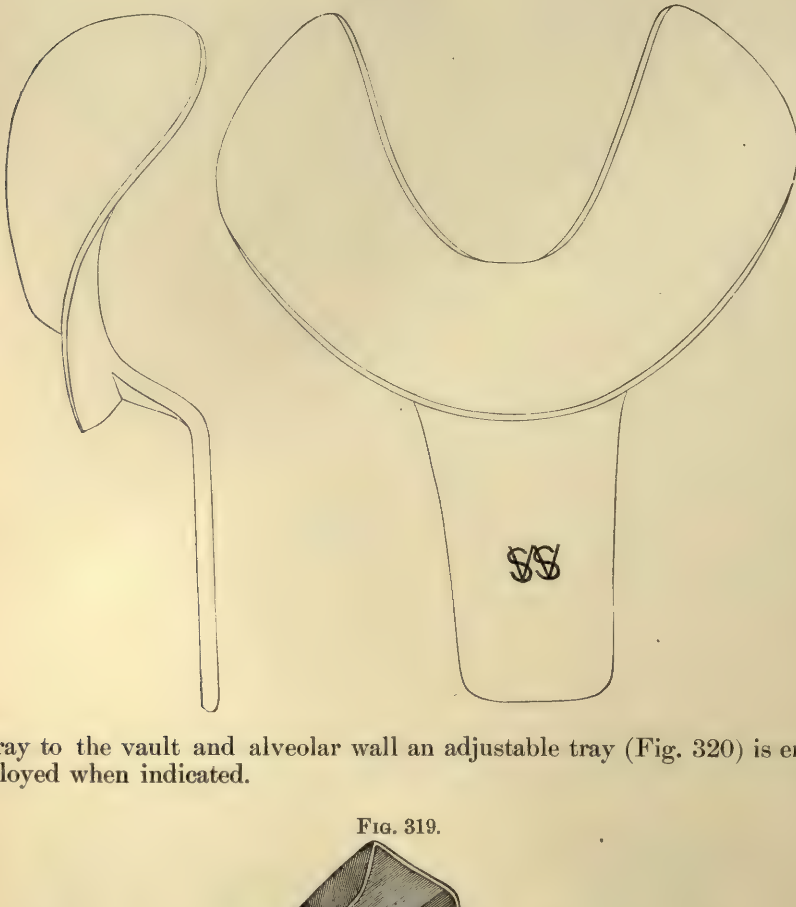
Fig. 317.



ing and cutting. It is necessary that lower trays should have their edges and outlines conform to those of the jaw, for assurance that the impression material shall be properly carried into position.

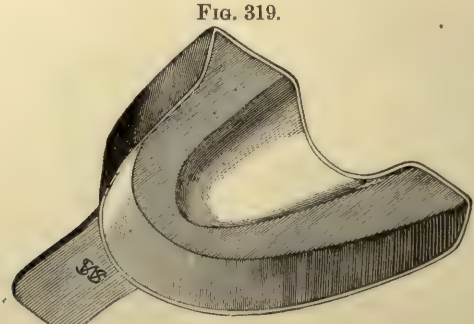
For partial upper dentures the form of tray shown in Fig. 319 will be found generally applicable. To ensure a closer adaptation of the

Fig. 318.



tray to the vault and alveolar wall an adjustable tray (Fig. 320) is employed when indicated.

Fig. 319.



For a common class of partial lower impressions a tray of the general form of Fig. 321 is employed, the edges of which shall extend at all points deeper than the plate line.

Where the remaining natural teeth are scattered, trays of the forms Figs. 322 and 324 are usually employed—Fig. 322 where the crowns of

the teeth are short; Fig. 324 when they are long. The adjustable tray, Fig. 322, may be adapted to different arch outlines.

FIG. 320.

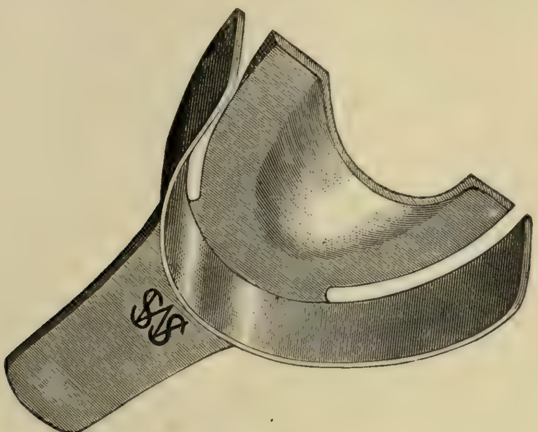
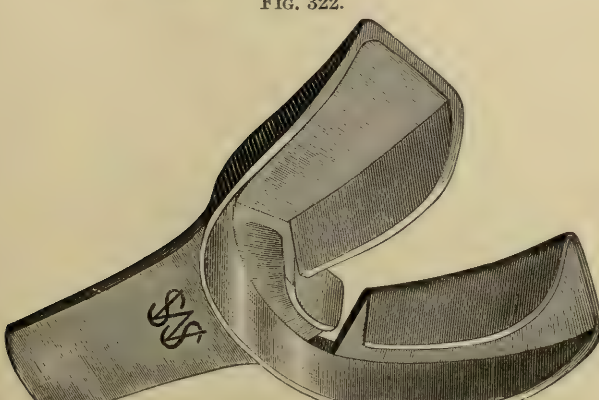


FIG. 321.

FIG. 322.



The impression trays as they are received from the manufacturer, while adapted for the taking of impressions of the majority of cases, are

frequently found to require alteration of their forms or outlines to adapt them to odd cases.

The requirements of a proper cup, that its outline shall embrace more

Fig. 323.

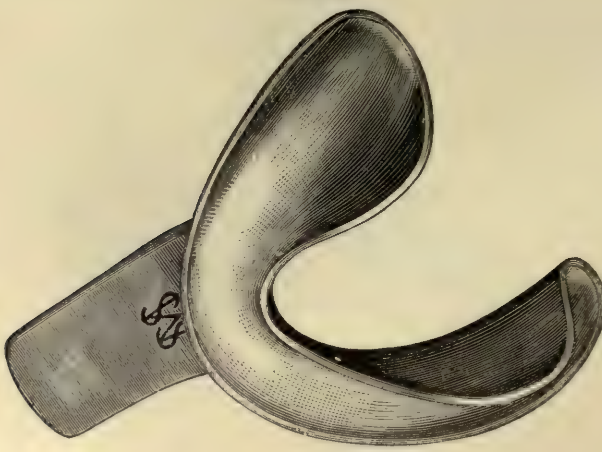
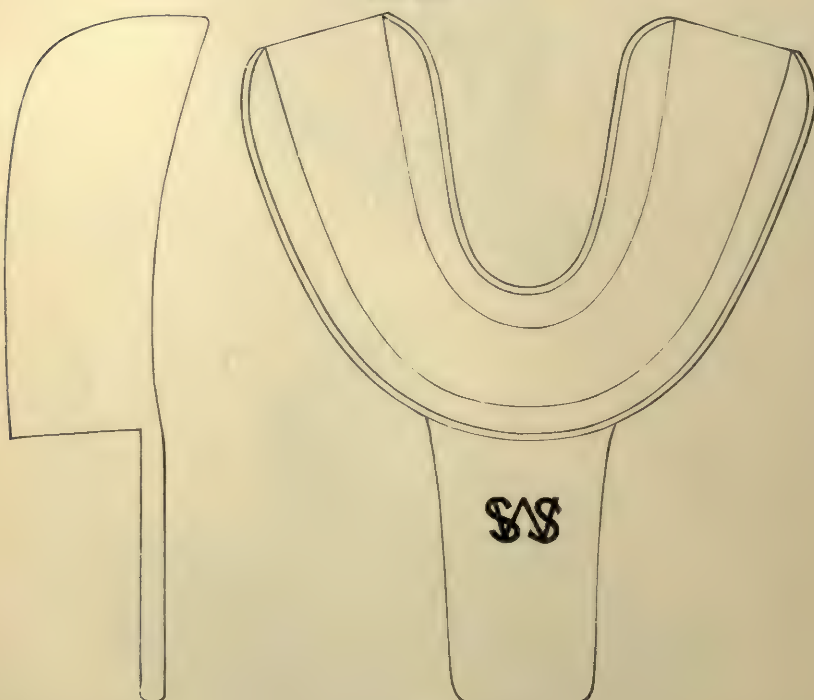


Fig. 324.



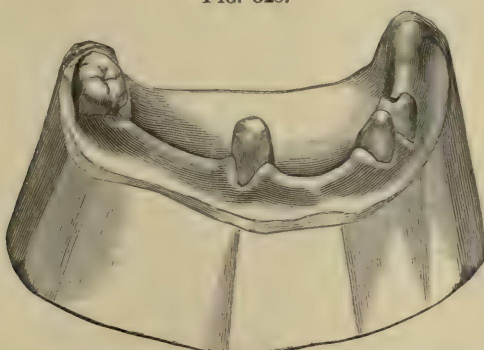
of the jaw than is to be covered by the plate, and to be at all points about a quarter of an inch larger than the jaw, show that many cups in their

original forms are not correctly applicable. It may be that a close correspondence between the tray and alveolar arches is not to be had in the original form of the tray, or, again, some portions of the edge of the tray may impinge upon the fræna or upon the mucous membrane reflected from the cheek or lips.

In adapting trays to full dentures the former are to be bent by means of pliers when it is necessary to alter their outlines to conform with those of the alveolar arch. Any edges of the tray which may impinge upon the soft tissues are dressed down by means of shears and files until a proper adaptation is secured. Heavy plate-nippers are employed to cut out the tray about the site of a frænum. The cut edges should be rounded and smoothed before the impression is taken.

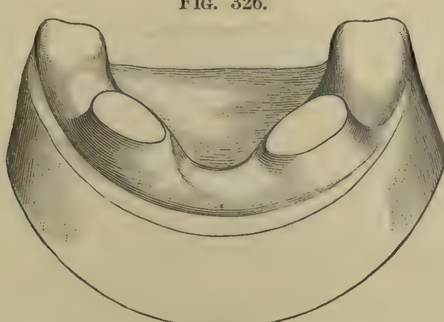
The necessary changes to a tray for a full denture are best or most accurately made by forming a plaster model in a wax impression, then by means of pliers, files, shears, nippers, and the horn mallet bring an approximate tray into the correct position of about one-fourth of an inch larger at all points and parts than the model.

FIG. 325.



Special Trays.—It is occasionally found—more frequently in such partial lower cases as is illustrated by Fig. 325—that none of the ready-made trays can be altered sufficiently to form a correct tray. It may be necessary to make a special tray. A large wax impression is taken and

FIG. 326.



a plaster cast poured. The cast is warmed, and covered completely, at the portions to be embraced by the cup, by a layer of wax at least one-

quarter of an inch thick. The wax is made thicker about the necks of the teeth—about half an inch thick or more; small spaces between neighboring teeth are to be filled flush with the general surface of the wax.

A heavy zinc die and counter-die are made, as described in Chapter X., and a piece of sheet brass No. 22 is swaged to cover as much of the die as should be embraced in the impression cup. A long strip of the same metal doubled on itself serves as a handle; this may be attached by means of a soft solder.

The principle embodied in the following method is one of wide application—viz. that the plaster covering the vault and arch should be of uniform thickness, and to ensure that it shall be carried into position in such a layer it is necessary that the cup should be properly adapted to that end.

Dr. J. B. Bean's Method of Preparing Trays and Taking Impressions.— A wax impression of the arch and vault are taken, and a plaster model made: over all of the surface to be embraced by the future plate, and for about half an inch beyond it at all points, a layer of wax having a uniform thickness of about one-eighth of an inch or more is placed. Dies and counter-dies are formed, between which a stout brass plate is swaged. The tray is thrown into nitrous acid, washed in soap and water, and dried in sawdust, which develops a surface resembling frosted gold.

The tray is heated and two coats of thick shellac varnish are applied (the tray is lacquered). While the shellac is soft a ball of cotton is pressed into the interior of the tray, and when the lacquer has hardened the cotton is drawn away, leaving small tufts which have been caught and retained by the shellac.

The impression is taken in plaster: the small volume of the latter lessens any tendency to nausea, and its even distribution equalizes any possible changes in the plates consequent upon its expansion. Moreover, there is an increased accuracy, due to the plaster being carried with certainty into all parts. After the plaster cast has been poured, the tray is heated until the shellac is softened, when the tray is removed and the model separated from the impression.

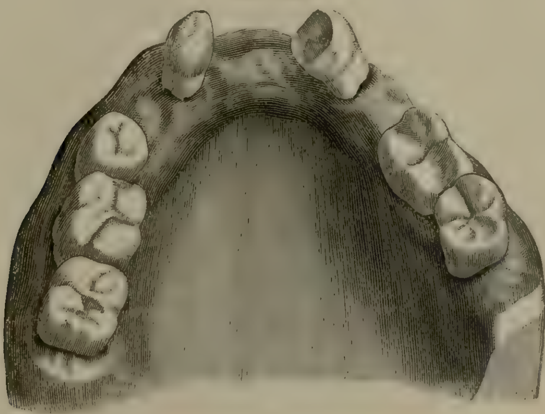
Selecting Material for Impressions.—Plaster of Paris is justly regarded as the impression material *par excellence.* It is extremely exceptional in the making of an artificial denture that its construction is not preferable upon a basis of an exact reproduction of the mouth in a plaster model. Plaster is the only impression material which possesses the properties which give assurance of accuracy. It is inserted without the exertion of any force which could cause the displacement of movable parts, may be insinuated into minute spaces or irregularities, and after setting its form is unalterable. The practised operator secures with this material impressions of any jaw, no matter what the anatomical peculiarities may be. Impressions may be taken with it of partial cases in which no two of the remaining teeth are parallel[1] (Fig. 327).

A general rule more applicable than any other is that "just in the degree that an impression is difficult to take, owing to irregularities of form or in the positions of the teeth, it is imperative that it should be taken in plaster." The exceptions to this rule are so rare as to scarcely require mention.

[1] See *Cosmos*, Nov., 1895, "Old Dentures."

Of the several materials made plastic by heat, modelling compound is usually regarded as having the widest field of usefulness. When soft it is sufficiently plastic to receive imprints of fine lines, and yet it inevitably displaces to a greater or less degree the soft tissues against which it is pressed. If the natural teeth are in irregular positions,

FIG. 327.



portions of an impression are bent from their true form when the impression is withdrawn from the mouth. The material being in some degree elastic, this deformity tends to partially correct itself. It may be mentioned that the most common use of this material is for securing impressions from which to form orthodontic appliances.

Pure beeswax becomes softer than modelling compound and at a lower temperature. When soft it is inelastic: although receiving the imprints of fine lines, it exhibits no tendency to adjust itself to undercuts, as does the compound. Additions of paraffin or gutta-percha to a basis of wax render it firmer. All preparations of wax are distorted permanently, to some degree, in being withdrawn from undercuts.

Gutta-percha, a substance once employed to some extent, has fallen into general disuse as an impression material, being replaced by modelling compound, the latter possessing more virtues and fewer disadvantages than gutta-percha. The last-mentioned material requires a comparatively great amount of heat to soften it: during the operation of impression-taking it is driven into irregular spaces, from which it is difficult to withdraw it when the material is cold.

Impressions in Heat-softened Materials.—Impressions in any of these materials are taken after one common principle: A properly adapted tray is selected or when necessary is fitted: the material itself is placed in lukewarm water, the temperature being raised gradually until the mass is of uniform softness. The tray is heated sufficiently to cause the material to adhere to it, when the impression material is moulded in the tray until of almost uniform thickness, except at its highest part, where it is left thickest to ensure perfect contact with the height of the vault.

The patient is seated in a dental chair placed at its lowest position, the operator standing behind. The tray is held in the right hand, two fingers

under its body, the thumb on the handle. The right side of the impression tray is to have its middle engage and draw away the lips at their angle; the fingers of the left hand draw away the left angle of the lip when the handle of the tray is swung into the median line; by a steady movement the impression material is now pressed into position: the fingers of the left hand are swept around the alveolar wall, so that the cheek shall not interfere with the perfect placement of the impression tray, which is now firmly held in place by two fingers pressed against the bottom of the sides of the tray. The patient is directed to contract the cheeks and lip against the impression material. When the latter is cold it is to be withdrawn, the fingers of the right hand holding the tray as during its introduction, the fingers of the left hand lifting the cheeks and lips away. The impression is plunged immediately into cold water to chill and fix it.

In taking the impressions of lower cases the operator usually stands in front of the patient. The same directions apply in the taking of these as in upper impressions. As soon as the material is pressed into position the patient is directed to protrude the tongue, so that the adjacent portion of impression will be pressed into position.

Plaster Impressions.—For the taking of any plaster impressions a properly adapted tray is essential. It is necessary that its outlines should be larger and greater in depth than the future denture. Between the tray and the arch and vault should be a space of about one-quarter of an inch—rarely less, except at the posterior border of upper impressions, as very thin layers of plaster are liable to fracture in pieces too small for accurate replacement. With a greater distance between the tray and the parts of which an impression is to be taken there is danger that the plaster will not be properly carried into position.

For full upper cases trays having a raised heel (Fig. 316) are employed, or a layer of wax is built across the heel so that the plaster cannot escape posteriorly.

Each fresh purchase of plaster should be tested, so that the length of time required for setting may be determined. Impression plaster should set more rapidly than that used for casts, but should permit thorough mixing and placing before it begins to harden.

Arranging Patient to Take Impression.—The patient should be seated, and instructions given as to position and the reasons therefor; the patient inclining the body slightly forward, and in readiness when the plaster is introduced to allow the head to be thrown still more forward, the object being to determine any excess of plaster to the front of the mouth and prevent it from falling into the fauces. Too many directions and an ostentatious preparation will, however, cause failure with timid patients, by inducing undue nervous irritability from a magnified fear of the operation.

When about to take a plaster impression a towel or large napkin should be spread in the front of the patient's dress to receive any excess of plaster which may be dislodged.

The patient may be directed to dry the mouth with a soft napkin if there is an excess of saliva, but this is rarely if ever necessary in taking impressions of the upper jaw, and some mouths are naturally so dry that the difficulty is rather to prevent the plaster from adhering too firmly to

the tissues. In such cases it is not well to absorb what little moisture there may be. Some operators always direct the mouth to be rinsed with warm water, which, it is claimed, by removing the mucus facilitates a more even flow of the plaster, diminishes its liability to an undue adherence to the membranes, and produces a smoother and more delicate impression. Some always brush the parts over with glycerol if the mucous membrane appears abnormally dry.

Before introducing the tray some operators instruct the patient to breathe through the nostrils, considering that the liability of fragments of plaster being drawn into the pharynx is much increased when the patient breathes through the mouth.

The late Dr. Joseph Richardson took, however, an opposite view, arguing that in the act of breathing through the nose the velum palati is depressed to cut off the passage of air through the mouth, and is thus brought more immediately in contact with any portion of plaster that may be protruding from the heel of the tray; that the stimulus of contact produces involuntary contraction, and that thus fragments of hard plaster may be drawn back into the fauces, producing the very evils which nose-breathing is thought to avoid; and that if patients are instructed at all in this respect, they should be advised to breathe through the mouth.[1]

About a gill of water is placed in a rubber plaster-bowl (Figs. 328–330) and a pinch of salt added. These bowls of soft vulcanized rub-

FIG. 328.

FIG. 330.

FIG. 329.

Rubber bowls for mixing plaster.

ber cannot be broken; their sides can be pressed together to form a lip or spout for pouring thin-mixed plaster; and any unused plaster of the mixing which sets in them can be thoroughly crushed and readily removed by squeezing the sides of the bowls together. Their superiority has made for them a place in almost every dental laboratory. Plaster is slowly sifted into the water until it is at the surface of the

[1] J. W. White: *Taking Impression of Mouth.*

latter, when it is stirred with the spatula until a thin paste is made. A quantity of the batter is carried into the tray and distributed by means of the spatula until it is something more than a quarter of an inch in depth.

FIG. 331.

Spatula or palette-knife.

The tray is carried into the mouth as described: its posterior edge is first brought into position, and then by a gradual elevation of the handle of the tray the plaster is carried into all depressions; the cheeks and lips, lifted away, are allowed to fall back against the plaster which has pressed over the edges of the tray, carrying it into close contact with the alveolar walls. The impression is now held immovably in position until by test of the plaster remaining in the bowl it is seen that the impression is hard. The lips and cheeks are lifted from the impression; the handle of the tray is elevated to detach the heel of the impression, which is now withdrawn.

Should the case present an unusual depth of palatal vault, air may be enclosed between the soft plaster and the mucous membrane and produce flaws in the impression. It is advisable in such cases to fill the tray with plaster; then a portion of the batter is taken on the end of the spatula-blade and carried into the height of the vault, smearing the plaster into the deepest recesses: the plaster in the tray is immediately carried into position, joining the plaster of the tray with that in the vault.

It is occasionally found that patients have what are called "irritable throats," the presence of any substance in contact with the soft palate causing any degree of protest from a slight gagging to marked retching or even vomiting. It is necessary, in such cases, to temporarily benumb the parts to enable the operator to secure an impression. The usual means of securing this end is through the employment of a gargle of camphor-water (not spirits of camphor). This suffices in many cases: the more irritable ones are directed to employ a gargle of potassium bromide, gr. xx, water an ounce.[1]

Should these means not suffice, the patient is given a gargle of glycerin and water; after a thorough lavage with this the soft palate and pharynx are sprayed with a 1 per cent. solution of cocaine hydrochlorate in an atomizer. In five minutes an impression may be taken without further difficulty.

In taking lower impressions the batter is made slightly thicker than for upper cases. The tray is carried into position, and before pressing it home a tremulous movement is made to introduce the plaster into undercuts; then it is pressed into position and firmly held upon both sides. The patient is directed to protrude the tongue to carry the plaster well against the alveolar wall anteriorly. Lower impressions are permitted to remain longer in position than those

[1] *Oral Surgery*, Garretson.

for upper dentures, for, being bathed in saliva, they set more slowly.

In taking plaster impressions the handle of the impression tray should always be in the median line, and the body of the impression should be held immovably in position supported upon both sides.

Any pieces of impression which may break from it during its removal are carefully preserved and fitted into their proper positions. The plaster when fully set breaks with a clearly defined fracture line, furnishing a guide for the accurate replacement of fragments or sections.

Cases are occasionally met with where the patient complains of the instability of a denture now worn: an examination shows an apparently accurate adaptation of the plate to the vault and the teeth in proper occlusion. Removing the artificial denture and passing the finger over the area of the vault and arch, it will be observed that the tissues do not offer uniform resistance to pressure; certain areas are hard, others soft or spongy, so that a plate closely adapted to the mouth at rest would exert uneven pressure upon its bed. Many operators prefer for such cases beeswax or modelling compound as an impression material, which by pressing away the soft parts should cause a plate made upon such models to have a uniform bearing. Unfortunately, this one feature of these materials rarely compensates for their lack of accurate adaptation to the parts and the danger of change of form in them.

The offices and advantages of wax or compound and plaster are combined in the following method: An impression is taken either in wax or compound; then by testing the density of the tissues the hard areas are determined and the impression is carved away at these parts. The prepared impression then serves as an impression tray in which an impression in plaster is taken. The greatest pressure is evidently exerted by those portions of the improvised tray which have not been cut away, those beneath the soft areas.

Dr. B. H. Catching[1] describes a method of quickly making special impression trays, for which the operator's ingenuity will devise many applications: A piece of base-plate wax is moulded to fit approximately the parts to be enclosed by the tray. This when removed from the mouth—or model if it be formed upon a model—is chilled and a wax handle formed. A plaster matrix is made of the tray in an exterior and interior section. The walls of the matrix should be thin. After separating the halves of the matrix the wax tray is removed, the matrix bound together, and the space formerly occupied by the wax is filled with molten fusible metal. If the tray is to be made of an alloy having a higher melting-point, the matrix is to be formed in sand and plaster mixture and well dried before the metal is poured.

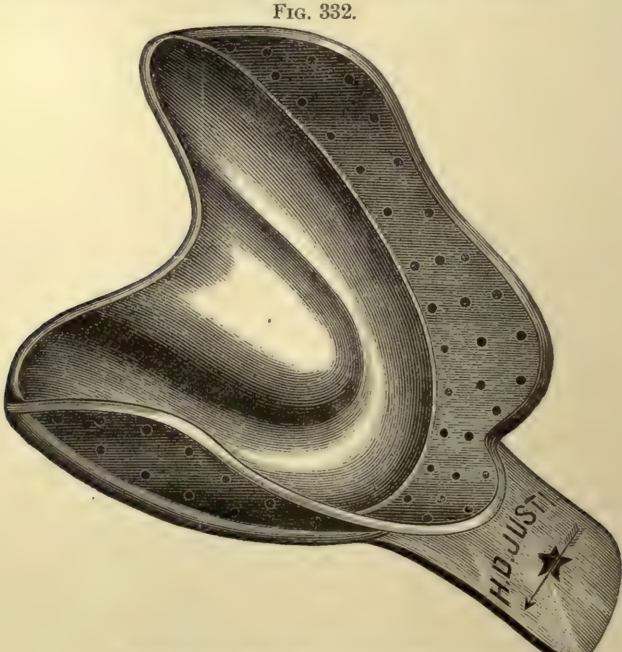
Impressions for Partial Dentures.—The necessity for a properly adapted tray is redoubled in the taking of impressions for partial dentures. One of the square-edged trays illustrated is selected whose arch is a quarter of an inch larger than that of the teeth. Closely fitting trays frequently cause the plaster about the natural teeth to break into such small fragments that accurate replacement of them is impracticable. Across the heel of the cup a dam of wax is built, so that the plaster will be well enclosed and none or but little of it shall escape posteriorly. Any

[1] *Comp. of Pract. Dent.*, 1895.

further lack of adaptation is to be corrected by building wax about the borders of the tray or cutting away from the latter parts which may interfere with its proper placement. The tray is filled with plaster—an examination of the comparative sizes of the tray and mouth will indicate the quantity of plaster required—and it is carried into position in the manner previously described. When the plaster and tray are in position they should be held by the fingers of both hands to ensure against rocking. When the plaster has set the cheeks and lip are raised from the impression, and the latter is loosened by depressing its heel.

It is usual, and in many cases inevitable, that there is a greater or less amount of fracture of partial impressions. The body of the impression, that in the tray, is set aside, and all broken pieces are lifted away with a pair of tweezers and ranged around the tray. An examination is made of the spaces about and between the teeth and any fragments found are detached and preserved. As soon as the impression is dry enough, in about fifteen minutes, each fractured surface is brushed free of any adherent particles (the brush should be very soft). The greater masses are now adjusted to one another, and the shapes of the spaces between parts of them noted; the pieces which fit such spaces are selected from the smaller fragments and set in position until the surfaces of the impression are complete. The pieces should be so adjusted to one another as to make the lines of junction almost indistinguishable.

FIG. 332.



Weirich's new flexible-rim impression trays.

Melted adhesive wax is applied to each joint upon the exterior of the impression to hold the pieces in their positions. Small pieces which it is impossible to thus attach without applying wax to the inner surface

of the impression may be made to adhere by treating the surfaces to be joined with thin mucilage (Fig. 332).

The impression tray of Dr. Weirich is designed for the taking of impressions of the forms which suffer fracture of their outer walls in withdrawing them from the mouth. The soft plaster exudes through the perforations of the flexible rubber rims when the tray is carried into position in the mouth. When hardened the plaster is thus held firmly against the flexible wall. As the impression is withdrawn from its position it fractures above the sites of undercuts : the flexible rim yields, and yet holds the broken sections firmly, and when removed from the mouth the elastic rim carries these sections back exactly into position.

The operation of taking partial lower impressions is essentially the same. The tray is to be one-fourth of an inch larger than the arch at all points, and the edges of the tray are to extend beyond the plate outlines. The most common classes of cases, those in which the anterior natural teeth are *in situ*, are taken in the variety of tray made for them. (See Fig. 321.)

Where the natural teeth are present at irregular intervals, trays having square edges, such as figured, are employed ; if the teeth are very long, trays such as are shown in Fig. 334 are applicable.

It is usual that these impressions suffer extensive fracture in their removal.

A tray filled with plaster is inserted, and before pressing it fully into position is jarred, so that the plaster will be brought into perfect contact with all portions of the dental arch. It is then pressed into place, and held until it has set hard. Cases in which the natural teeth are in an unbroken line usually fracture less than those in which the teeth are scattered. The pieces, large and small, are collected and each is accurately fastened into position.

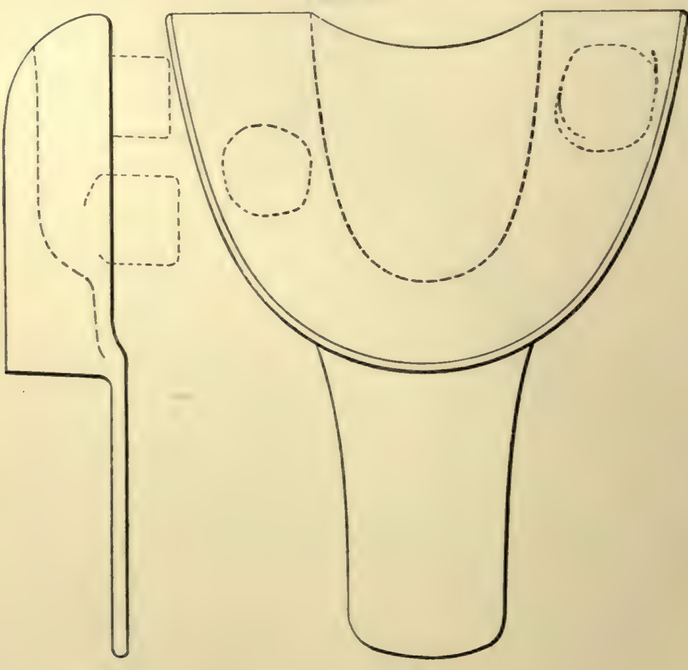
Should the spaces between the teeth present marked undercuts, or should any of the natural teeth be loose, it is advisable to remove the impression in sections in such a manner as to produce no strain upon loose teeth and to preserve the shapes of undercuts. This applies equally to partial upper cases in which similar conditions are present. A square-edged cup is selected and its inner surface oiled. The positions of the natural teeth are noted—which of them are loose and inclined. The tray and plaster are carried into position as before, and when the impression is hard the tray is withdrawn, leaving the impression in the mouth. With a sharp knife-blade groove the impression along a line which will pass through the middle of the articulating face of each tooth. When the groove extends to the crowns of the teeth, transverse cuts are made from the outer wall of the impression into the buccal or labial surfaces of the teeth : these grooves mark the impression into inner and outer sections and into two or more sections anteriorly. The tip of a finger is introduced beneath the edge of a posterior section, and it is detached ; the remaining outer sections are removed in the same manner. A finger introduced between the natural teeth exerts pressure upon the inner section of the impression, and it is pushed upon until loosened and detached. The writer has never met with a case, no matter how irregular, of which a plaster impression could not be secured by a careful following of this method.

The several pieces are adjusted to one another, and cemented together and to the tray.

It has been recommended in taking impressions for this class of cases that a wax impression be first taken, which is then carved out to serve as a tray in securing an impression in plaster. This method is applicable when there is but slight danger of fracture of the plaster in removing the impressions from the mouth, but when the irregularity of the parts embraced by the impression is marked enough to cause fracturing of the impression, many of the fragments of the latter will be found too small and too thin for accurate replacement. Moreover, the heat engendered by the setting of the plaster softens the wax matrix and frequently renders the accurate replacement of fragments impossible. For this reason it is better to secure the primary impression in modelling compound, cutting it away until it is of the proper size and form.

In cases which have remaining one or two unusually long natural teeth it is advisable to cut large openings in the tray which shall permit the ready placing of the tray in position (Fig. 333, *A*; 334, *A*). Without these apertures a tray rides on the natural teeth, so that it is difficult to prevent movement of the impression while it is setting. The setting of a thick mass of plaster about isolated teeth, which are frequently at an acute

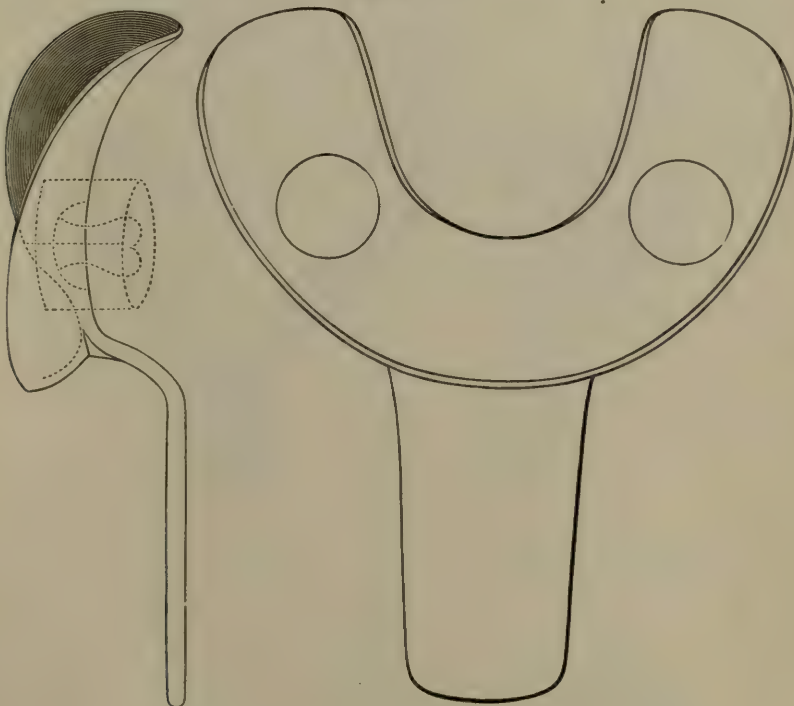
FIG. 333.



angle with the plane of the mouth, and which are broader upon their masticating surfaces than at their necks, renders it most difficult to remove the impression. About the openings cylinders at least twice as wide as the

teeth are attached (Fig. 333, *B*; Fig. 334, *B*): these may be made of the heavy pattern tin of the laboratory or of sheet wax: wax is melted about their bases to hold them to the tray. The tray, filled with plaster, is carried into position. The body of the tray should be well adapted to the

FIG. 334.



alveolar arch, so that the body of the impression is quite thin. When the plaster is hard the cylinders are stripped from the plaster. A groove is made along the length of the plaster projection until the knife-blade is felt to touch the enclosed tooth. Introducing a broad dull blade in the groove, the cylinders are split in two sections, making sharp fracture surfaces. The tray and body of the impression are now withdrawn, and the plastic cylinders adjusted and cemented to it. It is occasionally necessary, as has been stated, to alter the original forms of trays to make them conform to irregularities of the parts embraced by the impression. While slight alterations by cutting, filing, or bending may serve to adapt the tray in many cases, there are others in which it may be necessary to so trim a tray that it is out of all resemblance to its original form. At the site or sites of a column or columns of natural teeth it may be necessary to remove entirely those portions of the tray which interfere with the passage of the tray to within one-eighth of an inch of the vault. Instances and illustrations of this necessity and the modus operandi of making the changes are appended. Fig. 335 shows the tray in process of being cut by means of plate-nippers, the most expeditious means of making the

changes without that distortion of the general edge outline of the tray which accompanies trimming by shears. Fig. 336 illustrates a tray for a partial lower case cut out for the passage of the anterior teeth, the lingual wall of the tray being divided to accommodate an unusual confirmation of the lingual aspect of the alveolar wall. Fig. 337 shows a tray prepared for taking an impression for a partial upper case.

Fig. 335.

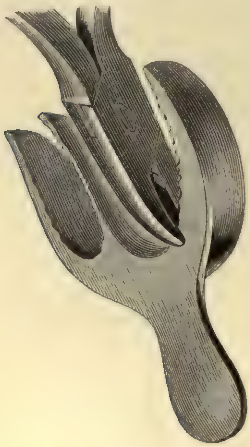
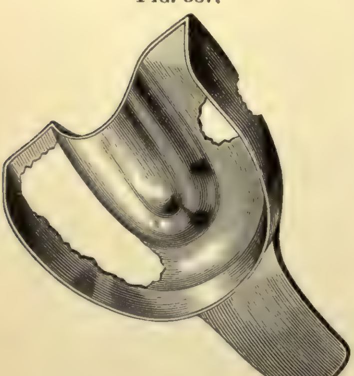


Fig. 336.

The trays, altered so that they will pass readily into position, have softened sheet wax moulded about the openings, forming chambers slightly deeper than the lengths of the teeth and about twice as broad. Their edges are cemented to the tray about one-eighth of an inch beyond the borders of the openings in the trays, so that the plaster of the impression will be caught by the under surface of the tray at these points and serve to withdraw the impression in the tray.

Fig. 337.



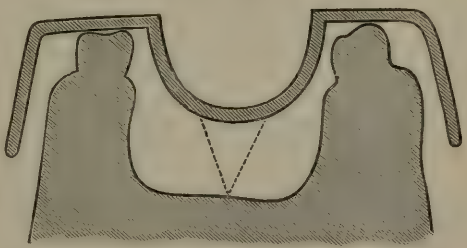
Cases are occasionally seen in which the plaster exhibits an undesirable tendency to cling to the surfaces of the teeth. To overcome this it is the usual practice to coat each natural tooth with olive oil before taking the impression. A ball of cotton is dipped in the oil, and then passed over the surfaces of the teeth. As in these cases the plaster tends to adhere to the mucous membrane also, the oiled cotton is to be passed over all portions of the mouth to be embraced by the impression. Dr. L. C. Ingersoll[1] advises mixing in the plaster batter about one-third of its volume of pulverized pumice.

In rare instances the natural teeth may converge toward one another, so

[1] J. W. White: *Taking Impression of the Mouth.*

that their walls, together with the palatal vault, form more than a hemisphere seen in section or semicircle (Fig. 338). It is evident that in such a case it would be impossible to withdraw *en masse* the body of an enclosed impression without displacement of these teeth. It is necessary that this portion of the impression shall be removed in halves. To render this division as easy as it should be, a wedge-shaped piece of modelling compound is placed along the median line of the tray, and deep enough for its sharp edge to be in contact with the palatal vault.

Fig. 338.



The impression tray is heated and roughened along its line of attachment to secure it firmly to the compound, which is chilled and the sides of the wedge made smooth and flat, then oiled, as is also the interior of the tray. The tray is filled with plaster and placed in the mouth: when hard the tray is removed and the outer portion of the impression detached. If the wedge of compound has not come away with the impression tray, a hook instrument is inserted in its posterior wall, and by this means it is detached. The right and left segments of the impression may now be removed without difficulty.

Occasionally it may be required of the dental operator to take an impression of an arch in which one, or it may be several, of the teeth are loose, and it is designed to retain them until a fixture is ready to be inserted, so that the patient may be spared the annoyance, humiliating to morbidly sensitive persons, of exhibiting vacant spaces in the dental arch. The greater number of these cases are those suffering from some phase of pyorrhœa alveolaris. The teeth are recognized by the operator as being past hope of retention, and the patient protests against their forcible extraction, preferring to await the inevitable exfoliation. In such cases a tray is adapted: its inner surface is oiled, and the tray is withdrawn from the impression, which is then removed in sections to avoid stress upon the loose teeth.

Unusual care must be exercised in these cases, as the danger of extracting the loose teeth in withdrawing the impression is not remote. Particular care must be observed to secure an accurate impression of the gums and gingival margins.

If the case be one for which a new plate is to be made, the plaster teeth are cut from the model, and the plaster cut away, representing accurately the appearance and form of the gums when the loose teeth shall have been lost. This trimming, while following with exactitude the gum outline which will be left at the site of each lost tooth, should be of sufficient depth to ensure the close adaptation of the future plate to the natural gum.

In taking impressions for cases requiring palatal restoration either of hard or soft palate, or of both, it is required that an accurate impression be secured of all of the edges of the opening representing the anatomical deficiency. An examination of the anatomical parts will exhibit the

palatal structures as a partition-wall between the nasal and oral cavities: it is evident, therefore, that care must be exercised and means adopted which shall prevent the entrance into and the retention of the impression material in the second, the nasal chamber, an impression of which for present purposes is not required.

An effective method for securing the desired impression is that devised by the late Prof. Geo. T. Barker, and employed by him almost exclusively. A piece of soft sponge is trimmed to approximate the form of the break, and make slightly larger than it; the sponge is to be softened in warm water. The sponge is then saturated with a batter of impression plaster, placed and held carefully in position until the plaster has hardened. The sponge is then carried backward to separate it from the parts and permit its removal. Its under (the lingual) surface is trimmed smooth, varnished, and oiled, and replaced in its position. The case is now one to which the ordinary methods of impression-taking apply, except that the extent of surface is greater. An extension of tin or of wax is cemented to the heel of an appropriate impression tray, this extension to be long enough to carry the plaster to the posterior pharyngeal wall. The tray is filled with plaster, carried into position, and held until the material has hardened. The impression is withdrawn, separating it from the sponge section, which is next detached and set in its proper position in the body of the impression.

In taking impressions of cases of fractured maxillæ, for which interdental splints are to be made, no attempt at the full reduction of the displacement is attempted. Plaster of Paris is the impression material to be employed, as its proper manipulation in these cases is attended by the exhibition of less force than with any other material. A large impression tray is selected, its surfaces are freely oiled, a plaster batter is placed in it, and the tray is carried into position. When the plaster has hardened the oiled tray is detached, separating readily. The impression is next removed in sections, which are adjusted to the tray, cemented together, varnished, and a plaster cast poured. The further steps of these operations will be described under the head of "Interdental Splints" in the chapter on "Dentures upon the Vulcanized Caoutchouc Base."[1]

Impressions into which molten metal is to be poured are taken in a mixture of plaster and marble dust, pumice, or whiting, the mixture requiring a greater length of time for setting than does plaster alone. The impression is placed in an oven and carefully and thoroughly dried: it is now set in a bed of moulding sand, which is built up around it to any depth it is desired to have the metallic model. The metal, usually tin, to serve as a base upon which a vulcanite plate is formed is poured in the impression and sand walls. Impressions taken in this mixture are by some operators made to serve as soldering investments for bridge-pieces.

Models of what are known as the fusible alloys may be poured in plaster impressions as soon as the latter are removed from the mouth: such models are never to be subjected to a temperature above 150° F.

[1] C. J. Essig.

CHAPTER VII.

MAKING OF MODELS AND THEIR PREPARATION.

BY H. H. BURCHARD, M. D., D. D. S.

IMPRESSIONS of modelling compound receive no treatment preliminary to pouring the plaster cast, except that they are dipped in water and the surplus of the latter shaken out, leaving a moist surface over which the plaster batter will flow freely. When the cast is hard the modelling compound separates readily from its surface when the impression is softened by heat. Wax impressions receive a coating of thin sandarac varnish prior to forming the cast; then, if the wax is not made too hot, it will separate from the plaster without adhesion to its surface. Without the interposition of the layer of varnish the wax exhibits a tendency to cling to the cast.

All of the pieces broken from a plaster impression in its removal from the mouth are to be carefully preserved and fitted to their proper positions. This detail frequently requires the exercise of much patience, but when it is considered that any defects existing in the impression are reproduced in the model, and that the success of a finished piece depends primarily upon the accuracy of the model, it becomes evident that time spent in carefully putting together a broken impression is ultimately time saved.

Each piece is fastened into position and the impression attached to the tray by means of adhesive wax. At the completion of this operation it should be noted that the impression is in accurate contact with the cup, that the lines of fracture are but hair lines, and that all edges are closely adapted to those of the tray. Any minute imperfections may be remedied by placing small pieces of softened wax in them, and by means of a spatula making it flush with the surface of the impression.

Separating Media.—It is necessary to coat the surface of the impression with some medium which shall prevent the adhesion of the plaster of the cast to the impression, and yet be of such tenuity as not to obliterate any of the fine lines of the latter.

A wash of soapsuds is employed in some laboratories as a separating medium. An ounce of Castile soap is placed in a pint of water, which is then heated until the soap dissolves. This solution is painted over the surface of the impression while the latter is still damp, and as soon as the impression is glazed the cast may be poured.

Thin solutions of collodion painted over the surface of the impression will glaze its surface and prevent the adhesion of soft plaster.

The method most commonly and acceptably employed is by double

varnishing the impression. After the latter has set for about half an hour, long enough for it to harden perfectly and yet not dry out, a large camel's-hair pencil is dipped in shellac varnish and a thin coating applied to all the surfaces of the impression: this speedily soaks into the substance of the plaster. Every part of the impression is to be colored a light brown. This coating should not be thick enough to glaze the surface, as it is the coloring, not the separating medium proper. When the shellac is dry a uniform coating of sandarac varnish is applied: this should give a glaze to the surface of the plaster, and yet should not be thick enough to obliterate any fine lines. It is the practice in some laboratories to apply a third coat, one of oil. This is quite unnecessary; moreover, should there be the slightest excess of the oil that portion of the plaster in contact with it is made soft, and this may injure the model.

Several varnishes have been suggested one coat of which shall serve the double office of coloring the impression to some depth and glazing its surface. These varnishes must not be thick enough to obliterate any of the fine lines of the impression.

Should the case be one in which there are isolated, long, or irregular teeth whose plaster forms are liable to fracture in separating the model from the impression, or which it may be desirable to subsequently remove from the model, long toilet pins are thrust into each tooth impression: when more than one tooth requires support, see that the pins are as nearly parallel as practicable.

With lower impressions it is a general practice to cut a piece of sheet wax to fit between the inferior edges of the impression, so that a flat surface is made representing the floor of the mouth.

The prepared impressions now represent matrices in which a model is to be cast which shall be an exact reproduction of the jaw in plaster. This cast is to be so made that it exhibits no blemishes on its faces or defects in its substance; not a line or depression is to be seen on its surface which is not there in consequence of its presence in the impression. The immediately succeeding operation, although apparently of great simplicity, is a procedure in which few become expert and a less number masters: it is that of forming the model making the plaster cast.

There are four primary requisites for its proper performance: The first, the preparation of the impression, securing a uniform and dry glaze on its surface, without destroying any of its fine details. Second, the proper variety of plaster: this, when set, should be much harder than the impression, should mix readily with water without the formation of lumps, should set slowly, and when poured upon a smooth surface should glaze. When hard it should have no suggestion of pastiness about it, cutting as a crystalline body, and not, as inferior plasters do, as a semi-glutinous mass. The best plaster is that known as the coarse Eastern[1] variety. Its particles appear much coarser than those of ordinary plaster, and are more distinct; it appears drier; it does not set perfectly for several hours, but after some days acquires a brick-like hardness. Italian image-makers employ it for making casts. Many of these casts, when examined, are seen to have a perfectly smooth surface, and yet have been made of the coarse plaster. This is explained by the statement

[1] Made in Nova Scotia and Maine.

that the coarse particles are surrounded by a powdery plaster, which, when the mass is poured, fills the spaces between the coarser particles. The next, the third requisite, is that the plaster shall be properly mixed with water, combined with it to form a paste which shall be perfectly smooth and semifluid. The last requisite is that this paste shall be perfectly applied to every portion of the surface of the impression. Aside from a rough surface of a model caused by improper preparation of the impression or faulty mixing of the plaster for the model, the most common cause of blemishes or flaws will be found in air-bubbles entangled in the soft plaster and leaving spaces upon the model unfilled by plaster.

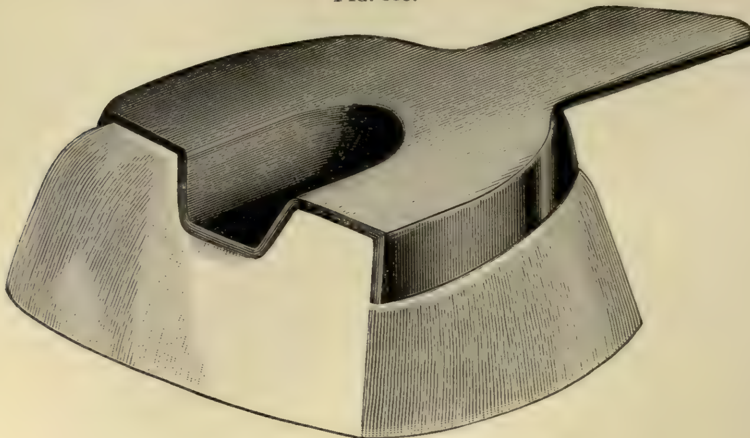
Pouring the Cast.—Plaster flows poorly over dry surfaces, so the surface of the impression is wet and the surplus water shaken out. Should the impression have become unusually dry, it is immersed until air-bubbles cease to rise from it; this will render separation from the model easier. As a preliminary step Dr. Essig advises making a thin, smooth batter of plaster, which by means of a camel's-hair pencil is painted into the deepest portions of the impression and into its fine lines.

If the case is one for which a metal plate is to be made, the model is to be thicker and broader than if the plate is to be of vulcanite. Casts for vulcanite are made never less than three-quarters of an inch thick at the thinnest parts; those for metal at least two inches thick. Assuming that the model is to be for a metal plate, about half a pint of water is placed in a plaster-bowl, without salt or any substance to hasten the setting of the plaster or which would cause deterioration of a model. Into the water plaster is slowly sifted, so that in the passage through the water each particle is wet: the sifting is continued until the surface of the plaster is level with that of the water; the mixture is now thoroughly stirred with a spatula until a perfectly smooth paste is made which shall flow freely and yet not be too watery. The impression is held in the left hand, its distal angle elevated; the ball of the hand is resting upon the edge of the plaster table. A portion of the plaster is taken upon the end of the spatula and placed at the elevated heel of the impression; now, by a continuous jarring of the hand upon the edge of the table the plaster is made to flow forward, driving all air from the deepest portions of the impression. More plaster is added and jarred into place, and more and more added as the plaster ceases to flow until the impression of the teeth and that of the alveolar walls is filled. The tray is now placed in a horizontal position, additions of plaster made and jarred into place until the impression is more than full. The plaster in the bowl, now beginning to thicken, is taken in larger quantities, laid upon the cast, and thoroughly spatulated: the additions are made until the mass of plaster represents an inverted pyramid, the distance from the edge of the tray to the base of the pyramid being about two inches. The spatula is passed around its walls, smoothing them as shown by Fig. 339, and the mass is inverted upon a piece of glass and permitted to set thoroughly.

The method of pouring the cast is the same irrespective of the impression material. If this be of wax or modelling compound, the base of the cast is set on a warm stove-plate or upon anything which shall now gradually raise the heat of the cast and impression to something

less than 200° F. When the impression is made as soft as when prepared for the mouth, a finger is caught under a lateral border, and the

FIG. 339.



softened material is drawn entirely away from the walls of the model. The heel of the impression is next loosened; then by steady traction the body of the impression is withdrawn. The wax, if a wax impression, should be softened, not melted, as in the latter case the surface of the plaster becomes infiltrated with the wax.

If small portions of modelling compound adhere to the face of the cast, the softened impression which has been removed is pressed against them; they adhere to it and are removed.

With due care two casts may be secured from one modelling-compound impression. One cast is poured, and when hard is set in cold water to below the edge of the impression. The water is slowly raised to the softening heat of the compound, when the latter parts readily from the wet cast, being withdrawn by steady traction in the direction of the axes of the teeth. Of course the soaked model is unfit for laboratory use; however, it may serve for comparison after the working model is destroyed. The impression is immediately chilled and a second cast poured.

Separating Plaster Impressions.—In separating a plaster impression from the cast it is quite possible by undue haste or carelessness to irretrievably damage the latter. The practised laboratory workman removes an impression from a cast without even slight mutilation of the parts or surfaces of the latter, no matter what irregularity may be present, such as long, irregular teeth or undercuts. As in putting together broken impressions, infinite care and patience are necessary.

The sides of the cup are first freed of plaster, so that none of its edges interfere with the removal of the tray. The tray is tapped lightly from side to side and across its bottom until it is seen to loosen from the impression. Should the latter be for a full denture, the plaster overlying the alveolar ridge is scraped away until approach to the cast is shown by entrance to the layer of plaster which has been colored by the shellac varnish.

It has been recommended to color the water into which the plaster for

the impression has been sifted with aniline red, to furnish a guide in separating the cast from the impression.[1] This, however, does not provide the danger-signal that shellac varnish does. The latter, by coloring the impression to a limited depth, indicates when the knife is approaching the cast: in the former case the cast may be inadvertently marred by the abrupt passage from the red to the white plaster.

When the yellow appears as a continuous line, the upper edge of the impression is freed from overlying portions of the cast: a small knife-blade, introduced under the edges, removes the outer wall of the impression in pieces, separating it from the body of the impression at the yellow line. A blade introduced beneath its posterior edge dislodges the body of the impression *en masse*. If a full lower impression, the cast is cut away until all of the borders of the impression are free, when it is removed after the same manner.

In separating casts for partial cases the first object is the perfect freeing of the plaster teeth from the impression plaster. The highest (most prominent) parts of the impression are scraped away until the varnish overlying the tips of the teeth is exposed. Beginning at the masticating surfaces, the impression is chipped away piecemeal from the plaster teeth until they are entirely free, and for more than a quarter of an inch about the base of each tooth the cast is clear of impression. The alveolar portions are removed in sections; the body of the impression may usually be detached in one piece. At the completion of the separating process the cast should show no knife-marks.

Trimming the Model.—If the model is one over which a plate is to be made of one of the vegetable bases, it is cut down until less than one inch thick, and the surplus plaster beyond the lines of the mouth is cut away, leaving a model which may be set in a vulcanizing flask without requiring further trimming.

If to be reproduced in metal—that is, if a plate is to be made of one of the malleable metals—and dies are to be cast, the walls of the model are given a slope at all its sides, so that the broadest part is its base. The thickness of the model is not reduced at all.

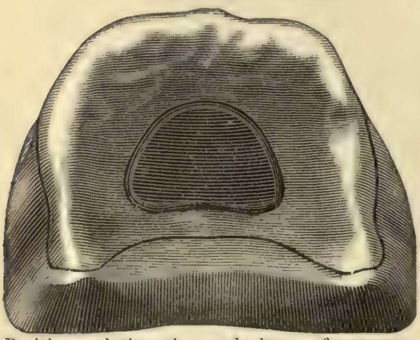
Any small and evident defects about the necks of plaster teeth or between them are to be corrected by means of a pointed blade, carefully trimming out the portions which represent the imperfections.

Marking the Plate Outline.—Upon the surface of the model the outlines desired in the finished plate are marked. It is first determined what may be the extreme limit of its posterior border. This must be anterior to a line affected by the movements of the muscles of the soft palate. The anterior limit of movement of these muscles varies with the individual: in one it may be posterior to the junction of the maxillary with the palate bones; in another it may be forward of a line joining the condyles of the alveolar arch. In flat mouths the line will, as a rule, be found comparatively far back; in high arches it is frequently found forward. The limit-line is noted by having the patient make the sound *ah!* with the mouth wide open, and noting the line at which the muscular movements of the palate cease. The line will be usually found at about the line of the condyles; the posterior edge of the plate is therefore curved forward from such a line.

[1] Dr. C. W. Spalding.

The alveolar edge of the plate is now to be marked. It should extend as far as possible up the buccal and lingual aspects of the alveolar wall, without impinging upon those soft parts affected by the movements of the cheeks or lips. Beginning at the frænum of the upper lip, the plate line is marked clear of this from the middle point. The plate lines now ascend in a curve to about the positions of the first bicuspids. The line now curves downward to escape the anterior edge of the buccinator muscle, and ascends again, enclosing the condyles and joining the line marking the posterior limit of the plate. In the mouth of one patient these lines may be nearly half an inch above the alveolar borders at their highest points; in another, less than one-fourth of an inch. The outline follows that of the mucous membrane reflected from the lips and cheeks upon the alveolar wall, and must be made to accord with it. Should the labial portion of the alveolar process be unusually prominent and high, so that no increase of fulness is permissible, the natural gum not having lost its normal contour, the plate is not carried over the labial wall: its anterior edge is drawn along a line which is that of the necks of the incisor teeth. The usual outline for a full upper plate is shown in Fig. 340.

Fig. 340.

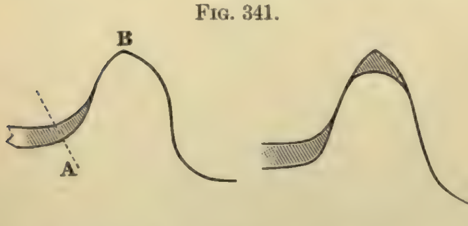


Position, relative size, and shape of vacuum-cavity for broad palatal arch.

In marking outlines for a full lower plate, it is to escape, to be made clear of, the mucous membrane reflected from the cheeks, lips, and floor of the mouth, and to be cut well out at the insertion of the frænum of the tongue. The muscular parts of these regions carry the overlying tissues to higher points than indicated by the model, so that full allowance must be made in marking the plate outline. This is particularly notable in the movements of the frænum of the tongue.

In marking the outlines of a partial lower plate, they are drawn to represent the plate resting upon about one-half the lingual aspects of the natural teeth when these stand in columns; when there are isolated teeth, these are generally utilized for clasping and the plate is carried around their edges. The same rules are observed as to freedom from impingement upon the soft parts. When an isolated tooth stands perpendicular to the alveolar arch, the buccal line of the plate is made continuous, an opening being made in the plate for the passage of the tooth.

Fig. 341.



A common result attending the wearing of lower plates accurately fitting a model is a tendency to bury their buccal edges into the soft tissues. The precaution is taken to raise this portion of the plate from

the mouth, so that this tendency becomes impotent. A layer of wax is built over the outline of this portion of the plate edge about one-eighth of an inch deep, immediately over the line, and shading to a feather edge where the wax comes in contact with the alveolar wall. Raised from this edge, the pressure of the plate is greatest at the height of the ridge at *B*, Fig. 341. This precaution is always taken for partial lower plates.

Where the crest of the ridge is represented by a sharp edge, it is usual to place over it a layer of wax about one-sixteenth of an inch in thickness, the same precaution to be taken in raising the plate edge. This throws the greatest pressure of the plate upon the alveolar walls. If not raised at the crest, a plate will bear too hard upon the underlying soft tissues and cause distress.

Any areas of the arch or vault enclosed in the plate outline which represent hard nodular parts are to receive a coating of wax, so that when the soft tissues yield to the pressure of the plate, the latter will bear uniformly upon all parts of its base. In lower cases these nodular areas are most commonly or nearly always found at some part of the lingual aspect of the alveolar arch. At about the site of the first bicuspid is the usual situation. In upper cases they are almost invariably found occupying the median line of the vault, in a position which would underlie the posterior portion of the plate. They commonly mark the junction of the palatal processes of the superior maxillary and palate bones.

It has been advised in such cases to scrape from the impression itself, before pouring the cast, a layer of plaster just thick enough to represent the yielding of the soft tissues. This method, although satisfactory in many cases, alters the model and does not give full assurance of accuracy, so that the method to be preferred is to make a perfect model and reverse the procedure: build wax over the prominences to a depth equalling the scraping of the first method. These protuberances may extend so far forward as to demand change in the configuration of the plate outline; this will be discussed later.

Vacuum Chambers.—These are concavities made in the palatal aspect of the plate which, when the plate is in position in the mouth, have the air partially exhausted from them, and the atmospheric pressure upon the lingual surface of the plate causes the latter to adhere to the surface of the vault.[1] There is a lack of harmony of opinion as to the utility of this device, many maintaining that its office is either but temporary or that it is unnecessary. A majority of prosthetists have, however, an abiding faith in its permanent utility. It is important that these depressions be properly shaped and correctly placed. The following description will illustrate the means of determining their positions:

The slight movement usual with a plate during mastication tends to separate it from the mucous membrane and permit the access of air to its under surface.

The line of least movement, as the movement is lateral, a rocking from side to side, is along the median line of the vault; and as the concavity of the hard palate is usually of an irregular vault form, the point of least movement is near its apex. If the movement does not extend to an edge of the chamber, the stability of the plate is not materially

[1] *Dental Cosmos*, vol. xxxvii.

affected, but when one of these edges loses its contact, air enters the chamber and adhesion is destroyed.

The more closely the edges of the chamber approximate this line the less tendency to disturbance there is, so that comparatively narrow chambers are to be preferred; but the depression should be of sufficient size to not materially lessen the effects of partial vacuum.

Naturally, the chamber should be in the area of greatest stability, that of least movement.

This area will be found around and about the centre of gravity, and in shape resembling the outlines of the dental arch.

The dental arch represents, approximately, a parabola in outline.

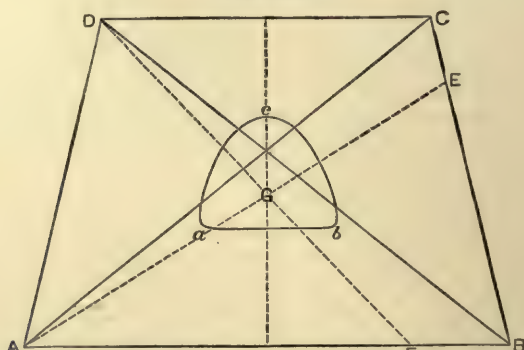
This encloses a trapezoid, the centres of the cuspids marking the extremities of the short, the centres of the third molars those of the long, parallel side. Straight lines, joining these points, complete the figure.

The centre of gravity of a trapezoid is found by suspending it first by one obtuse angle, and next by one of the acute angles; vertical lines dropped from the points of suspension will, in intersecting, mark the centre of gravity.

Thus, on the diagram (Fig. 342, *A*, *B*, *C*, *D*), suspend it first from the angle *A*, *D*, *C*, and drop a vertical, *D*, *F*.

Suspend from the angle *B*, *A*, *D*, and drop a vertical, *A*, *E*. Their intersection at the point *G* is the centre of gravity, which is posterior to the intersection of the diagonals.

FIG. 342.



A, *B*, *C*, *D*, trapezoid of the superior dental arch; *G*, centre of gravity of figure; *A*, *G*, *E*; *D*, *G*, *F*, gravity lines, their intersections marking *G* (Burchard).

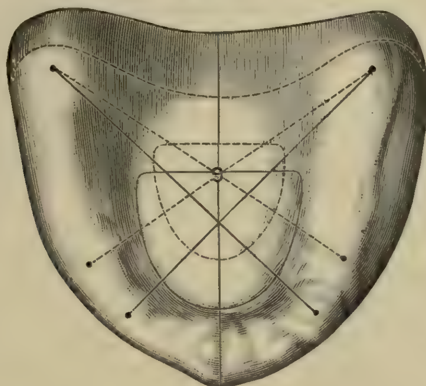
About the centre of gravity the vacuum chamber should be placed, its outline following that of the arch, on a smaller scale. In the vast majority of cases the centre of gravity thus determined will be found at about the height of the vault.

The ends or apex and angles of the chamber should be about equidistant from the centre of gravity—as a rule, the apex of the chamber as far in front of the intersection of the diagonals as the centre of gravity is behind that point.

To apply these facts practically as a guide to finding the correct position of a chamber, draw first on the plaster model the median line

of the vault. From the centres of the cuspidati to the centres of the third molars draw diagonal lines, the diagonals of the trapezoid. When all the teeth are absent, draw from the positions formerly occupied by the cuspidati to the centres of the condyle the two diagonals (Fig. 343).

Fig. 343.



To find the centre of gravity, draw from the centres of both condyles lines to the junction of the first and second bicuspids of the opposite sides other lines, which intersect at a point of the median line *G;* this point will be the centre of gravity of the trapezoid and of the palatal vault. The intersection of the diagonals will mark the focus of the small parabolic area to be covered by the chamber-piece. Draw this parabola, its apex, about as far in front of the point of intersection of the diagonals as the centre of gravity is behind the latter point, the angle of the parabola the same distance from the centre of gravity as the apex. Should there be a lack of harmony, of bilateral symmetry of the right or left side of the arch outlines, make the outline of the chamber in correspondence.

Fig. 343 represents a model, having the outline of an old chamber too far front; the correct position is marked behind it, also the lines which have determined its position. It may be remarked, parenthetically, that an increased stability was secured by correcting the position of the chamber in this case.

To form the chamber-piece, fold a small strip of paper, and lay the line of fold along the median line of the arch, and on the surface of the paper draw one-half the outline of the chamber area. While folded the paper is cut along this line, unfolded, and is now the pattern for the chamber-piece. If of metal, mark the shape of the paper on the metal and cut out, and fix in position by means of a pin at the apex and at each angle.

If of wax, cut from a sheet of gutta-percha and wax base-plate (which is usually too thin by half for chambers). Make this cut firmly and sharply. Soften the wax slightly, flow over the height of the vault a little melted adhesive wax, and press the wax chamber into position, the outlines of wax and pencil-marks corresponding. A warmed spatula is used to smooth the edges of the chamber, which should be sharp, dis-

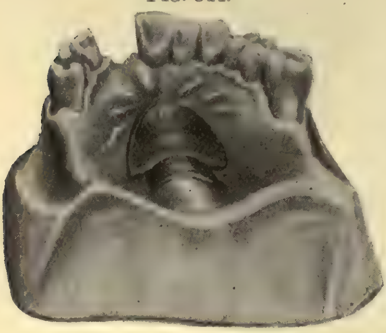
tinct, and a slight slope given to the walls. Chambers which have not sharp outlines do not afford firm adhesion.

I have followed this little plan for at least ten years, and in that time applied it to thousands of cases, and believe with better results than had haphazard placing of a chamber been practised.

Plates should by all means be made without chambers if without it they still fulfil all the requirements for a good piece; but experience has taught that this result is the exception, and not the rule.

The foregoing description applies to the average vault: peculiarities in the configuration of the latter may demand modification of the form or of the position of the chamber. Nodular areas which underlie that portion of a correct plate line, which the posterior portion of the plate and the posterior edge of the chamber would embrace, demand change of principle. Where these protuberances are exactly in this position a satisfactory adhesion is occasionally had by first covering the nodular areas with wax, then adapting the wax chamber model, making its posterior portion very shallow (Fig. 344).

Fig. 344.



Should the protuberance extend well into that portion of the plate area covered by the vacuum chamber, it is usually necessary to carry the posterior edge of the chamber forward of the anterior edge of the elevation, giving the heel of the chamber a concave form (Fig. 345).

Should the elevation lie entirely in an area which would normally be embraced by the chamber, a thin wax chamber model is cut and adapted to cover it, its edges bearing upon the soft tissues around the base of the elevation.

In some instances the disturbing element may occupy so much of the

Fig. 345.

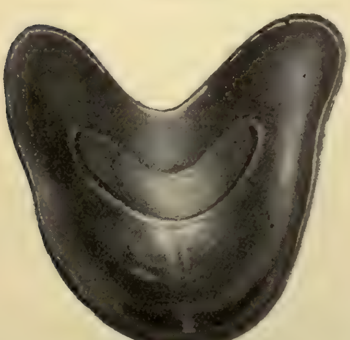
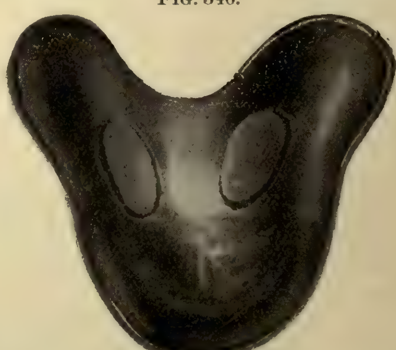


Fig. 346.



height of the vault that a median chamber is inadmissible. A weak adhesion is secured by means of what are known as lateral chambers (Fig. 346). These are made small, oval, and comparatively deep, the

edges nearest to the height of the vault to impinge upon the soft tissues at the base of the hard elevation.

What are known as horseshoe chambers are applicable where the hard area does not extend too far forward.

Dr. U. B. Kirk noted in his practice a case in which adhesion could be secured only by the form of chamber shown by the dark shading in Fig. 347.

Fig. 347.

In all of these odd chamber forms the walls of the wax pieces should be trimmed at such an inclination that no undercuts are formed; each chamber wall should be almost paralled with the axis of the model, and each should be sharp and distinct. The junction of the chamber-piece with the face of the model should be sharply outlined.

If after trial in matrix-making (Chapter VIII.) it is found the sand drags about the wax chamber-piece, the latter must be trimmed to overcome the difficulty: the angle of its walls with its free surface must be made more obtuse.

The model is now ready for the succeeding stages of preparation.

Recalling now that from this model a matrix of moulding sand is to be made—a mould which shall be a reverse to every line of the plaster model—it is evident that the latter must be prepared so that it may be withdrawn from its bed without breakage or distortion of the sand. Bodies of shapes ranging from those of cones to those of cylinders may be withdrawn and leave a true matrix; but anything resembling a reversed cone would necessarily break or disfigure the sand matrix by its withdrawal.

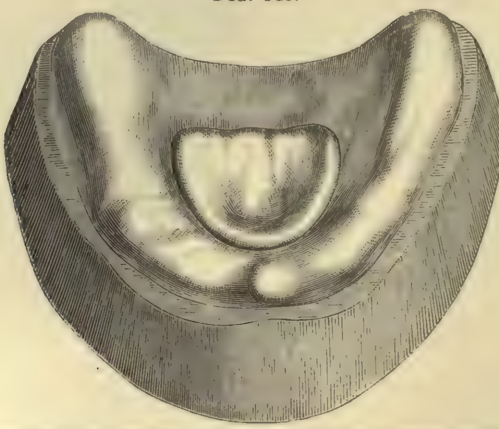
First, the model must be given a coating of sandarac varnish, glazing it faintly, so that the moulding sand will not adhere to it. Next, any depressions present at parts not to be covered by the plate are built out to the pyramid faces by means of wax; as, for instance, at the labial aspects of the inferior anterior teeth in partial lower cases.

Teeth which are much inclined from the vertical or which have such shapes as would complicate the moulding operation are to be removed. At about one-sixteenth of an inch above the surface of the model a saw-cut half through the plaster tooth is made; light force will now break the attachment of the tooth, and it is slipped from its pin support. The sharp line of fracture furnishes a guide in replacing the tooth after the dies are made.

It is occasionally designed, particularly for plates having all or part of the artificial gum formed of vulcanite, to form the alveolar edge of the plate into a rim. This form of rim is always employed with continuous-gum dentures. The method of preparing the model for this variety of dentures will be described in Chapter XIII, on Continuous-gum Work.

The edge of the rim, marking the height of the plate, must be at a line which shall ensure against reducing the plate after it is finished. At about one-sixteenth of an inch beneath the usual plate outlines a wall of wax is applied to the alveolar border of the model: the angle which this wax forms with the alveolar wall should not be more than a right angle, and if possible it should be acute. The ledge of wax is made perfectly smooth and clear cut: it should be something more than one-eighth of an inch broad. Its outer wall is to merge into the general walls of the model.

Fig. 348.



Cast of upper jaw, ready for moulding. The model for the vacuum-chamber is in position.

The experience of many skilled prosthetists has demonstrated an advantage to be gained through a judicious alteration of the face of a model. Vaults which exhibit defined areas of differing density are subjected to uneven pressure by a plate which is perfectly adapted to an accurate model. It is recommended that a careful topographical examination be made of the vault, and those portions found to be soft are to have the corresponding areas of the model scraped away as much as they will yield to the pressure of the plate. The portions to be trimmed are commonly in the height of the vault at both sides of the median line: between the apex of the vault and the beginning of its walls at their posterior portions will be found in most mouths areas softer than the other aspects of the vault. This method is particularly applicable for mouths where it is designed to construct a plate without a vacuum chamber.

CHAPTER VIII.

DIES, COUNTER-DIES, AND MOULDING.

By H. H. Burchard, M. D., D. D. S.

A die is the duplication of a model in metal made to facilitate the formation of some resistant substance into a plate which shall be perfectly adapted to the surface of the model.

A counter-die is the female die, formed by pouring over the surface of the die a defined block of a metal or alloy more fusible than the die.

The operation of moulding consists in forming in sand or any suitable medium a matrix which shall represent accurately a reverse impression of the plaster model: the die is formed by filling the matrix with molten metal.

The purpose of the latter operation and the implements produced by it is the securing of two metallic blocks of sufficient rigidity to permit the forming between them of a sheet of metal of a size, shape, and variety suitable to serve as a supporting base to an artificial denture—a lamina which shall be perfectly adapted to the surfaces of the alveolar ridge and palatal vault.

Moulding Sand.—Three varieties of sand are used in the dental laboratory for making matrices. The first and oldest is the finest grade of iron-founder's black sand; the second, the brass-moulder's brown sand; and third, marble dust. The last is used perhaps more frequently than either of the others: it is no better than the second variety—indeed, the writer believes the brass-moulder's sand gives the best matrices.

A sand for this purpose should be fine-grained enough to give a smooth surface to metals poured over it, and yet possess sufficient porosity when packed in a moulding ring to permit the escape of steam formed when molten metal is poured in a moist matrix, and should form a mass of sufficient coherence to maintain a given form and to permit the withdrawal of a prepared model from it without fracture. Marble dust has the two advantages of being more cleanly and retaining moisture longer.

Preparing the Sand.—Upon the preparation of the moulding sand will depend much of the success of die-making. The sand should be moistened uniformly and sufficiently to give a sharp line of fracture when a mass made by squeezing in the hand is broken, and yet be in such a condition that it will readily pass through the meshes of a fine flour-sieve. To attain or produce this condition care and deliberation are necessary. Twenty minutes is none too short a time in which to properly prepare three quarts of sand.

About a gallon of the sand is placed at one end of the sand-tray and gradually drawn toward the operator by means of the sand-crusher, pulverizing any lumps which may be present. It is now sifted, and hard lumps, fragments of zinc, lead, or other foreign materials thus separated are cast aside. The sand is spread over the floor of the sand-tray in an even layer, and sprinkled with about half a pint of water; it is then stirred and tossed with a broad wooden spatula, and then thoroughly rubbed with the sand-crusher for fifteen minutes or more, then sifted. The sieved sand should be tested by compressing a quantity in the hand; it should break with a sharp line of fracture.

There is an indescribable feel to properly prepared moulding sand with which the experienced moulder becomes familiar.

It has been recommended to substitute oil for water in the preparation of moulding sand, as the sand so prepared is always ready for use. This single advantage does not compensate for the dirty working of the material tempered by that medium. Its odor when heated by the molten metals is also objectionable.

Metals Used for Dies and Counter-dies.—The prepared model is to be reproduced in some metal which possesses the following characteristics: It should be hard enough to withstand the force of swaging without marked bruising of its surface; it should be tough and not brittle, so that it will not break; the degree of contraction should be low—that is, the mass should shrink but little upon solidifying; finally, it should be readily fusible in the common heating appliances of the laboratory, and when molten should possess a quick fluidity which shall permit of its flowing freely into small spaces. Of all the available metals, zinc alone possesses these several features, and is therefore in general use for the making of dental dies. The alloys of zinc do not answer as well for this purpose.[1]

The alloy known as Babbitt metal is frequently used for die-making. It has a lower index of contraction than zinc, is more fusible, and is more brittle. Plates made upon dies of this alloy fit the plaster model as they fit the die. In lower plates, particularly those for partial lower dentures, or clasp plates for the upper jaw, this is a desirable feature. Prof. C. J. Essig[2] regards the contraction of zinc as being a strong feature of recommendation for use in making dies for full upper dentures, for "it will be noticed that a plate fitted to a zinc die is found to be in close contact with the plaster model throughout the alveolar walls, but at the posterior edge it is short of contact; thus the greatest pressure is upon the ridge, and the danger of resorption of the tissues of the vault is avoided. With the greatest pressure along the ridge absorption occurs, but in the parts underlying those in which resorption is merely a physiological process. However, plates perfectly fitting to zinc dies when placed in the mouth are found to have accurate adaptation; the expansion of the plaster compensates sufficiently for the contraction of the zinc, and again the yielding of the soft tissues brings the plate in contact throughout its area.

The zinc of commerce contains a variable amount of impurities: samples derived from the ores of several localities show an inconstancy

[1] Essig's *Metallurgy*.

[2] See Chapter II.

of physical properties when formed into dies. The variety known as Bertha zinc appears to be about the toughest and most homogeneous.

There are many formulas published of alloys to which are given the general title of Babbitt metal. The formula best adapted for dental purposes is that of Dr. L. P. Haskell: containing the ratio of tin that it does, it is comparatively expensive, but the cheaper specimens are not serviceable as dies.

The alloy known as Babbitt metal is composed of tin, 72.72; copper, 9.09; antimony, 18.18. The alloy is largely a mechanical mixture. In melting it is seen that a portion becomes fluid, in which are suspended the crystals of the more refractory metals. In solidifying the base of a die is seen to exhibit distinct evidence of the differences of points of crystallization, one portion crystallizing, while others are still fluid.

For small dies the bismuth or cadmium alloys, known as fusible metals, are occasionally used: they are very brittle, entirely too frangible to withstand any but light blows.

Compounds known as Spence's metal have been in very limited use for the making of dies. They are sulphides of metals, dissolved by heating in an excess of sulphur.

The mixture and the method of using are described by Dr. E. H. Bogue:

"**Description of Process for Stamping Plates by Hydraulic Press.**[1] —Within a few years a material called Spence metal has been devised. This substance is really sulphur and iron. It melts at about the boiling-point of water, and in process of cooling a stage is reached, just before solidification takes place, at which the mass becomes exceedingly fluid. At this stage it can be poured into an impression of plaster or even Stent's composition.

"This circumstance has caused Spence metal to be used in the hydraulic press for the purpose of stamping dental plates, as a steady pressure of almost any power may be had by this means. It is also possible to make the dies and stamp a plate within two hours from the time of taking the impression. A description of a case in hand will perhaps best serve my purpose. In the present instance an impression was taken with Stent's material, and all the rest of the work was done by my friend and assistant, Mr. Fred. Collett. The impression was chilled with cold water, and sculptor's clay was built up around the margins to the height of half an inch. A paper could have been wrapped around equally well. The impression then was coated with a solution of soap and water. Into this impression, thus prepared, Spence metal, just before the point of solidification, was poured. This Spence metal was chilled immediately on touching the Stent's composition, so that all contraction took place from the top of the centre downward.

"The small die thus made was then provided with three legs made of pins heated and pressed into the metal. These pins held it at just the required height, so that the die, being placed in the middle of the iron ring in which the pressure was to be given, stood at the height required for an additional quantity of Spence metal to be poured into the concavity and around this little die up to the required level. This die,

[1] Read at the semi-annual meeting of the Massachusetts Dental Society, Boston, June 6, 1889, *International Dental Journal*, July, 1889.

being quite cold, is covered with whiting, and a counter-die of Wood's fusible alloy[1] is poured over it. This fusible alloy melts at a still lower temperature than Spence metal, and it is poured over the male die by using the heavy iron ring in which the counter-die must remain during the swaging process. This first set of dies being completed, duplicates are made, if required, by taking the impression of the male die and repeating the process of casting the dies as often as may be required.

"The Spence metal is exceedingly brittle, so nothing but steady pressure must be permitted. If it should be found necessary to use successive force, others must be made of some other material. In the present instance a Babbitt's-metal die with a tin counter-die was made upon which to break up the plate.

"The flat plate may be placed between the dies with a bit of glove-kid or rubber dam between the plate and the counter-die, and the flask containing it placed directly in the press. The screw at the top of the press being turned down to give such pressure as is possible from above, the second screw connected with the plunger at the side is then gradually turned inward by means of the large driving-wheel. The manometer is watched, as indicating the amount of pressure that is being given; four hundred pounds to the square centimetre is generally enough, though I have as an experiment run it up to twelve hundred.

"During the swaging process the plate should be frequently annealed. When finally down, close to the duplicate dies, it receives its last trimming, its last annealing, and is then put upon the original die that was made directly from the impression. When taken from the press after this final pressure, the fit is more perfect than any struck swages can make it.

"For suction-plates it is generally necessary to scrape the centre of the plaster impression and not to put in an air-chamber, the fit of the hydraulic-press plates seeming to be as good as the impressions from which they are made."

The material and method have not been adopted; but such a compound would serve well for the making of very small dies to which much force is not to be applied.

For general use zinc is to be employed for the dies for full upper plates and for the primary dies of all; Babbitt metal is most useful for making the finishing dies of all partial cases and for full lower plates, and also the finishing dies for the full upper plates occasionally made without vacuum chambers.

Metals for Counter-Dies.—The metals in use for making counter-dies are lead, an alloy of lead and tin, and zinc.

When molten these metals may be poured upon a zinc die without fusing the face of the latter, provided, of course, their temperature be not too high. Lead, because of its softness, is used as a counter to the first die, and it may be for the second or third die also; but the lead-and-tin alloy, being harder, is to be preferred for the final swaging.

Zinc is used as a counter-die for those cases presenting very deep and

[1] Composed of 15 parts of bismuth, 8 of lead, 4 of tin, and 3 of cadmium. This forms a silvery-white, granular alloy, which becomes soft at 135° F. (= 57° C.), and fuses at about 145° F. (= 63° C.).

irregular rugæ; also for swaging platinous gold. The lead-and-tin alloy is employed as a counter for dies of Babbitt metal. Type metal may be employed for the same purpose.

Moulding Flasks.—The moulding flasks of the dental laboratory have the forms of rings which have been flattened upon one side, corresponding with the general outline of the plaster model. They are made of several sizes, telescoping one over another. The largest sizes are used for enclosing the matrix, the smaller to deepen the matrix cavity and thus give increased thickness and strength to the die. A set known as the Bailey flasks is in general use (Figs. 349–351).

Fig. 349.

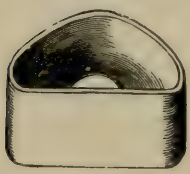
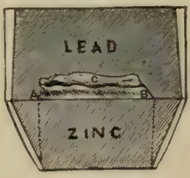


Fig. 350.

Fig. 351.

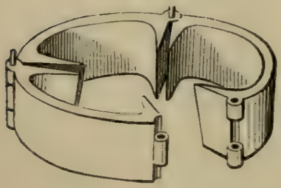


Bailey's flasks.

Dr. Uriah B. Kirk, an expert prosthetist, many years ago introduced as moulding rings sections of heavy five-inch stovepipe, having riveted joints. These sections answer admirably, as there is less danger of packing too tightly the large mass of sand contained in them than were the mass smaller. The writer has for several years used them with greater satisfaction. They are made about five inches deep.

A sectional cylinder, known as the Hawes flask (Figs. 352–354), is commonly employed for moulding cases presenting marked alveolar undercuts.

Fig. 352.



Moulding.—The prepared sand is placed to one side of the sand-tray; the model is set upon the zinc floor, and a large moulding ring is placed around it, using a size which shall clear the model on all sides at least half an inch. A pint or more of the sand is placed in a flour sieve and sifted over the face of the model, adding more and more until the ring is about half full; then, using the tips of the fingers, the sand is pressed on and about the model until it is packed firmly; more sand is added until the

Fig. 353.

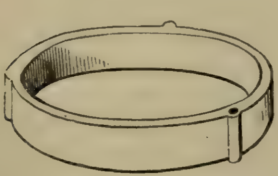
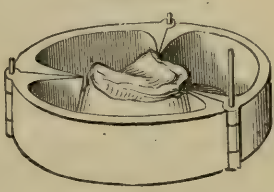


Fig. 354.



ring is more than full: it is pressed down firmly; then, using a broad sharp spatula or table knife, the sand is trimmed level with the top of the flask.

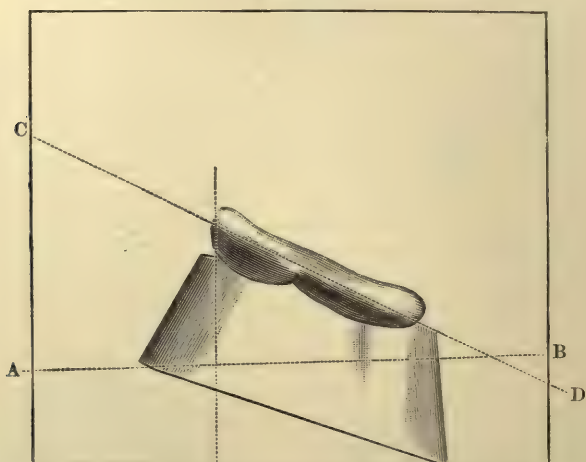
The ring is now inverted and placed upon the floor of the sand-tray; an old excavator having a tapering point is gently driven into the centre of the base of the model, and serves as a handle by which to withdraw the model from its sand bed. Using the handle of the smoothing knife as a percussing tool, the model is lightly tapped on all sides until it begins to loosen; then, grasping the projecting handle, a gentle traction is exerted upon the model, continuing the tapping, and the model is withdrawn. Another method of detachment is by holding the base of the model over a bed of sand made to receive it; it is tapped until it falls from the matrix. Another is to loosen the model by tapping upon alternate sides, then inverting over the sand bed and permitting the model to drop out. The first method described is to be preferred, as there is less danger of disturbing the matrix.

The mould is now examined: if it exhibits a coarse, porous surface, if any portions have broken away, which may be noted by ragged surfaces to any part of the matrix, it is to be rejected, and the moulding operation repeated until at least two good moulds are obtained.

If the case be one in which teeth are remaining, see that the outlines of each tooth be distinct, and also the lines between the teeth. Any teeth standing in such positions as to cause dragging of the sand in withdrawing the model from the matrix are to be removed before the moulding.

There are cases in which, despite repeated attempts, good moulds are not secured. One class of these cases is formed of those having an overhanging alveolar ridge, particularly at its anterior portion. If the undercut be not too marked, the front of the walls may be raised, bring the axis of this portion of the ridge nearer to a vertical line. An in-

Fig. 355.



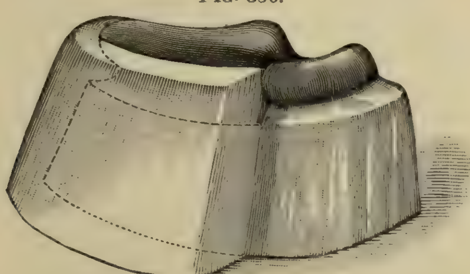
clined bed of sand is made, the front of the model resting upon its highest portion, the heel of the model upon the floor of the sand-tray: it is enclosed by a moulding ring, the sand packed as described, the ring inverted, the base of the metal freed from sand, and it is then detached by holding it over a sand bed and tapping: by this means moulds of undercut cases may usually be secured. If the mould be accurate, the

sand in the ring is trimmed to a flat surface, *A*, *B*. The matrix and ring are then set on an inclined bed of sand, so that the line *C*, *D* is almost or quite horizontal.

The undercut may be so marked that this expedient does not suffice, the sand breaking away at the part of the mould corresponding to the undercut. The device known as the Hawes flask is now in order. The model if too thick should be trimmed away at its base until the surface of the alveolar ridge is level with the jointed section. This section, with the pins fastening it, is placed in position about the model, and sand packed about the latter. The surface of the sand is made level, and powdered charcoal or talc dusted over it to prevent the sand of the superimposed section from adhering to it. The second section is placed in position and filled with sand, well packed and its surfaces trimmed flat. The second section is removed and placed upon a flat surface. The pin holding the sectional cylinder together is removed, and the cylinder is then carefully opened sufficiently to permit removal of the model. The cylinder is closed, the pin placed in its opening, and the second cylinder set in position over the first. Much care is required to secure accurate moulds with this device, and it may be the *dernier ressort* of the moulder will be necessary—the operation known as core-moulding.

Core-moulding.—At the site of the undercut the varnished surface of the model is oiled. A batter of 2 parts marble dust, pumice, or beach sand and 1 part plaster is used to extend the wall of the model to the shape of a larger pyramid. When this has set it is carefully

FIG. 356.



detached from the model, its external wall, upper and lower surfaces smoothed by means of sand-paper, then thoroughly dried over a stove: if used wet, bubbling of metal in contact with it will ensue. When it is cold it is placed in position on the model, and its outer surface and top are varnished. When the varnish has hardened, a mould is made which must be perfect, the outlines of the core being plainly marked. The core is removed from the model and placed in its position in the matrix, and its edges luted to the latter by wetting the sand along the line of junction. The matrix is dried before pouring metal into it.

Occasionally it is necessary to use cores for limited undercuts at the lingual aspect of lower cases. They are to be used in all cases where it is impossible to secure an excellent matrix without them. Usually a matrix accurate enough for the starting die may be made by the ordi-

nary method, the core used for the matrix of the finishing dies. Imperfect dies are to be trimmed as described later.

A smoother surface may be given the matrix and die by "sooting" the surface of the former, holding it over the flame of a candle.

Making Dies.—The ladles in which die and counter-die metals are melted should be plainly marked, to avoid mixing the latter. About three pounds of fine zinc ingots are placed in a ladle and melted in any of the laboratory furnaces. Where gas is not obtainable excellent gasoline melting furnaces may be used (see pages 25 and 26). The zinc is to be entirely molten before pouring; if used before it is perfectly fluid, or rather while an unmelted core remains in it, bubbling is almost certain to occur. If raised to too high a temperature, the zinc produces brittle dies. If old dies, and not zinc ingots, have been used, a quantity of scrap wax is thrown upon the molten metal, and it is well stirred, disentangling the oxides, which then float upon the surface and are skimmed off before the zinc is poured.

When perfectly fluid the zinc is poured into the matrix, holding the mouth of the ladle quite close to the ring. The matrix is poured nearly full; a smaller-sized moulding ring is set around the matrix and resting upon the sand: this is poured full or nearly full to give increased weight and strength to the die. In about five minutes the die and enclosing parts are freed from sand. The die is now examined for any imperfections: these when found are remedied by trimming with a sharp chisel.

The zinc when hot may be cut as readily as half-set amalgam; if permitted to cool, trimming is difficult. The second die is examined, and the better one of the two is reserved for a finishing die. If the case be one for a partial denture, the zinc teeth of the starting die are cut off by means of a small cold chisel to within one-sixteenth of an inch of the surface of the model, leaving a sharp edge to the stumps, so as to mark the plate in swaging.

If for a partial lower, the teeth on the first die are cut off to just above the plate line, and at an acute angle. As a rule, the teeth should remain on the finishing die.

If the dies are of Babbitt metal, the metal must be perfectly fluid before pouring: when the matrix is full a second ring is placed over it, and about a half inch of the molten metal poured in this, and the die is permitted to partially set before further addition is made. As stated before, this alloy is in great part a mixture, not a chemical compound, of the several metals, so that the most fusible constituents remain fluid for some time after the more refractory metal or alloy has set: if too much be poured, the fluid portions ooze from beneath the upper ring. Dies of this metal should be made very thick, as the alloy is much more brittle than zinc. They should remain undisturbed until it is seen from the surface that solidification is complete. They are to receive any necessary trimming while hot, and to be perfectly chilled and dried before pouring the counter-die.

Counter-dies.—The cooled dies are freed from sand, and, if they have been chilled by placing in cold water, wiped perfectly dry. Serious accidents have occurred through pouring molten lead upon wet dies. The steam confined between the two metals expands with explosive force and drives out and scatters about the molten lead.

Enough sand is placed in a large moulding ring, which has been inverted, to bring the plate line of the die a little higher than the edges of the ring; sand is packed about the die level with the edge of the ring. Around and over the die is placed another moulding ring.

Babbitt-metal dies and those which are to have zinc counters made over them are to have their surfaces blackened over an oil or gas flame, to prevent adhesion of the counter-die metals.

Counter-die metals are to be poured as soon as fluid. The temperature of molten lead is to be tested by thrusting into it a wisp of paper: if it merely browns the paper, it is at the proper temperature; if it carbonizes or ignites it, it is too hot.

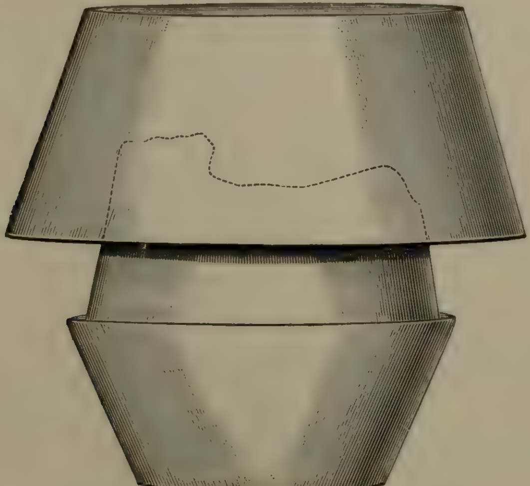
The lead-and-tin alloy, the counter-die metal used with Babbitt-metal dies, is to be poured while a small portion of it is still unmelted. Zinc for counter-dies is poured while a portion is still unmolten. When fluid the metal is poured in a small stream, but rapidly, until the ring is full.

In pouring counters for Babbitt-metal dies or in making zinc counter-dies do not permit the molten metal to fall from a height upon one point of the die; it tends to fuse that spot of the latter.

When the counter-die has set the mass is freed of sand and chilled in cold water. The die and counter are separated by drawing blows delivered upon the base of the die.

The counter-dies are then set upon an avil, the dies adjusted to them, and they are driven together by blows of a swaging hammer. In cases

FIG. 357.



Die and counter-die.

which present an unusually high vault and ridge it is advisable to use partial counter-dies to form the vault portion of the plate before any attempt is made to form that portion covering the ridge and outer alveolar wall. The writer has for ten years used a graded set of these partial counters for this purpose.

For the largest the die is imbedded in sand to the level of the sum-

mit of the ridge, and a counter-die poured as described. When this has been separated two or more pyramidal masses of lead, covering the height of the vault and about two inches high, are poured, almost drop by drop. These extend about half an inch beyond the borders of the vacuum chamber. The several dies and counter-dies are marked at their heels to designate the dies and counter-dies which belong together. They are brushed clean before using them.[1]

The methods described are those commonly practised, and which have survived the test of time. Other methods for making dies have been advocated, but they are more the nature of curiosities at this day than applied methods.

One of these processes is die-making by dipping. The plaster model has its chamber-piece made of plaster, and is left unvarnished. A sheet-iron basin some four or five inches in diameter, smaller at the base than across its uncovered top, is filled with molten zinc ; in this the face of the unvarnished model is thrust to above the plate outlines. When the metal has set the plaster is removed, the model being destroyed in removal. Around the depression representing the counter-die a moulding ring is placed, and the die is made of a metal more fusible than the counter-die. The counter-die may be smoked, and the die made of zinc also.

Occasionally dies have been made of the bismuth alloys called fusible metals. The sides of the impression being enclosed with a putty wall of the proper height, the molten metal is poured directly into the plaster impression.

Dr. B. W. Franklin[2] devised the means of securing counter-dies when this alloy is used for the die. A sheet-lead plate is burnished and pressed to fit the die ; this is filled with moulding sand and set upon a bed of the latter ; around it a moulding ring is set, and a counter-die made of tin or a low-flowing alloy. The die is reinforced by the addition of a brass head. A flattened pyramid of the latter metal, having a tinned base of three inches or more, is heated until the solder or tin is fused ; upon this surface the base of the die is set ; when the surfaces are united cold water is poured over die and counter.

These methods are rarely practised, as moulding in sand is preferable for obvious reasons.

[1] A similar method has been described by Dr. I. N. Broomell, *Internat. Dent. Journ.*, 1890.

[2] Richardson's *Mechanical Dentistry*, 3d ed.

CHAPTER IX.

SWAGED METALLIC PLATES.

By H. H. Burchard, M. D., D. D. S.

The sheet metals employed as bases of support for artificial teeth are gold, silver, platinum, and aluminum.

For a brief period sheet palladium was applied for the purpose. A chance overstocking of the market brought the commercial value of the metal to a price making it economically available for dental use. This, however, was but a curiosity in the history of dentistry. The present price of the metal places it beyond the list of those available for plates.

Palladium possesses almost the infusibility and insolubility of platinum, and has the additional properties of greater rigidity and a less specific gravity to recommend it.

Platinum is rarely or never used as a base-plate for soldered dentures; it is too soft and inelastic: its infusibility fits it for employment when covered by substances fusing at high temperatures, as where faced with porcelain continuous-gum work.

The alloy of platinum and iridium, known as iridio-platinum, is occasionally employed in the making of plates, the addition of iridium producing a very rigid alloy.

Under exceptional conditions plates may be made of the alloy of gold and platinum, called platinous or clasp gold; this, however, is rare: the alloy is, as a rule, only employed for clasps and to form supplementary pieces for strengthening the weak areas in plates made of more pliable alloys. It is employed when either rigidity, elasticity, or both, are required.

Aluminum is occasionally employed as a base-plate, the denture proper being mounted in vulcanite. Its lightness and comparatively easy working properties recommend it, its greatest deficiency being the impracticability of neatly and effectively soldering it. (See chapter on Aluminum, page 146.) The metals commonly employed are gold and silver, the latter used but seldom since the introduction of vulcanite.

Sheet gold for making plates is usually 18 carats fine; it should never be of less fineness, and if finer than 20 carats does not possess sufficient rigidity.

Silver plate is the 900-fine alloy known as coin silver. Pure silver is too soft. An alloy of silver and platinum is to be preferred to the coin silver; it is more rigid, and may be made more so by increasing the percentage of platinum in the alloy; it is less liable to tarnish, and has

a much better surface. It is much less rigid than platinous gold. (See Alloys of Silver, page 120.)

When the employment of a metal plate is an imperative indication, economical reasons alone prompt the use of silver. Gold is of all metals best adapted for the purpose; by varying the fineness of the alloy and its components any desired quality of plate may be obtained.

Indications for the Use of Metal Plates.—Metal plates possess certain advantages over those of vulcanite, celluloid, or even continuous gums, which are utilized when and where indicated. They are stronger, thinner, smoother, and have a greater conductivity than any of the vegetable bases.

Mouths in which it has been shown that plates constructed of vulcanite exercise an undesirable influence, owing mainly to the non-conductivity keeping the underlying structures at a constant temperature, a metal plate, preferably gold, should be substituted.

Metal plates are an imperative indication when the distance between the natural gums and occluding teeth is very slight, or when these latter in occlusion touch the gum of the antagonizing arch. The attachment of the teeth for such cases must necessarily be by means of solder, and a very thin plate is alone admissible; so that vulcanite, the stronger of the vegetable bases, is inadmissible.

Peculiarities of the Plate Metals.—In manipulating gold it must be frequently annealed, raising it to a dull red heat and plunging it into cold water. Under manipulation it soon becomes very elastic and obdurate, and must be reannealed as soon as this condition is re-established. 20-carat gold, while not as rigid or elastic as 18-carat, is not so homogeneous an alloy: although it is softer, it has a greater tendency to crack under manipulation, and much care must be exercised in working it over tuberosities and into undercuts. Gold may be stretched—that is, it exhibits its malleability under the operation of swaging—but, as this thins the plate, it is better to so manipulate the latter that it maintains a uniform thickness. It is to be pressed into position, not turned into it, as is done under the operation of spinning or raising sheet metal.

Particles of base metal must be kept from its surface: a particle of lead will form with the gold underlying it a brittle alloy, melting at a low temperature, so that when the plate is heated a hole is burned through the plate at that point.

Heavy sheets of gold, as indeed of any metal, work more smoothly and exhibit fewer wrinkles than thin sheets, but their adaptation is not so close. The latter require much care to work smoothly, the former much force, and generally a zinc counter-die to produce accurate adaptation to the die.

Platinum is annealed at a very high temperature, and then becomes very pliable, and offers a surface to which the base metals attach themselves closely; and as some of these latter form very fusible alloys, penetrating the substance of the platinum as soon as heated red, care must be exercised that the surface of the platinum be kept free from such contamination.

Silver is annealed at a temperature a little below red heat: its surface oxidizes quickly above that point, and it fuses with startling suddenness. This metal almost invariably suffers more or less change of form in heat-

ing. Although requiring less frequent annealing than gold, it is more liable to crack unexpectedly.

Aluminum behaves under the swaging hammer after the manner of sheet zinc. If annealed at too high a temperature, it becomes brittle and cracks readily; annealed and manipulated deliberately at a low temperature, it is tough and fibrous. More pressure than percussion is required to adapt it—the reverse of the platinoid alloys, which require hard blows to adapt them.

Palladium is at present never used, but should it ever become cheap enough for dental application, it is to be worked like gold.

Forming the Pattern.—The first step in the making of the plate is the important detail of forming the pattern. Due regard for economy suggests that the pattern be no larger than the plate itself—than is absolutely necessary. Gold plate in the condition of scrap has its commercial value diminished 25 per cent.

The pattern should be formed upon the die, to avoid the bruising of the plaster model.

A sheet of pattern foil about four inches square, and stout enough to require some force in manipulating it, is laid upon the die, and by the fingers is pressed into the deeper portions of the die: when adaptation is as close as can be made by such means the rubber tip of a lead pencil is used to secure a closer adaptation; this is succeeded by the pressure of small smooth points made of old tooth-brush handles until the pattern metal fits the die. It is marked by a sharp steel point along the plate outline, and a penknife blade applied to cut off the surplus metal. Patterns for partial plates should be cut out carefully at the necks of the teeth.

The chamber-piece should also be represented in a pattern, extending on all sides about one-eighth of an inch from the base of the chamber. Occasionally, in cases having an unusual distance from condyle to condyle, those in which experience demonstrates that lateral bending is a danger, the chamber-piece may be extended at the angles, forming buttresses to the plates (see Fig. 358).

Fig. 358.

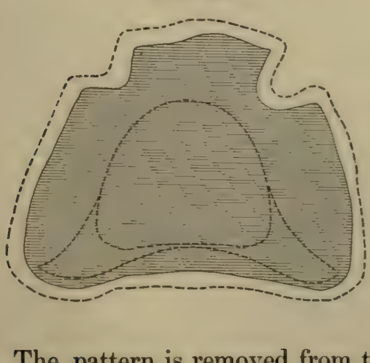
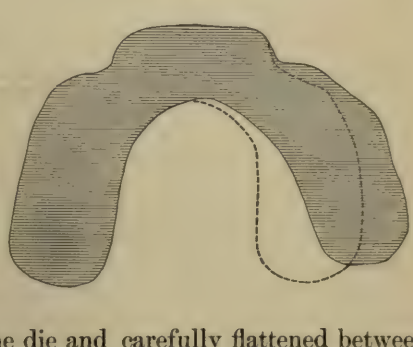


Fig. 359.



The pattern is removed from the die and carefully flattened between the fingers. It is then laid upon a sheet of cardboard, and an outline about one-eighth of an inch larger than the tin pattern is marked. Adepts in the laboratory require less margin, novices usually more.

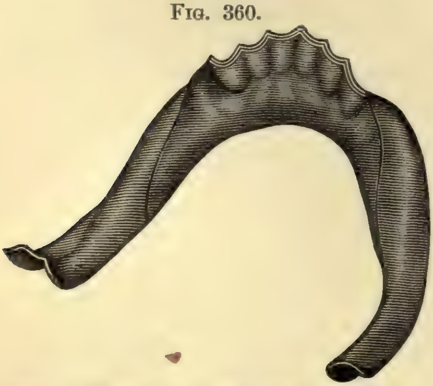
At places representing the necks of teeth the plate should always be cut with a rounded, never an angular, outline. Patterns for lower plates require additional care: the adaptation of the tin along the lingual aspect must be very accurate. It is a matter of some difficulty to accurately straighten or flatten these patterns, and it is of the utmost importance that no distortion occur in the operation. The true outline being represented by the solid lines (Fig. 359), it will readily be seen that if the pattern were bent to the outlines of the dotted line, a plate cut by such a pattern could not be adapted to the die with accuracy.

A greater surplus is allowed with partial lower plates, to compensate for the greater danger of the displacement of the laminæ in swaging.

For upper plates the patterns are duplicated in plates of No. 26 of the B. and S. gauge. The cap piece is to be of No. 28, or, under exceptional circumstances, No. 27; that is, where an increased rigidity of the plate is demanded.

Lower plates are usually made of two laminæ of No. 29. In partial lower cases, across the space occupied by natural teeth, and to about one-half an inch beyond on both sides, a piece of platinous gold No. 27 is fitted as described below: without this supplementary piece these plates bend too easily (Fig. 360).

Fig. 360.



Partial lower plate, with reinforcing piece in position.

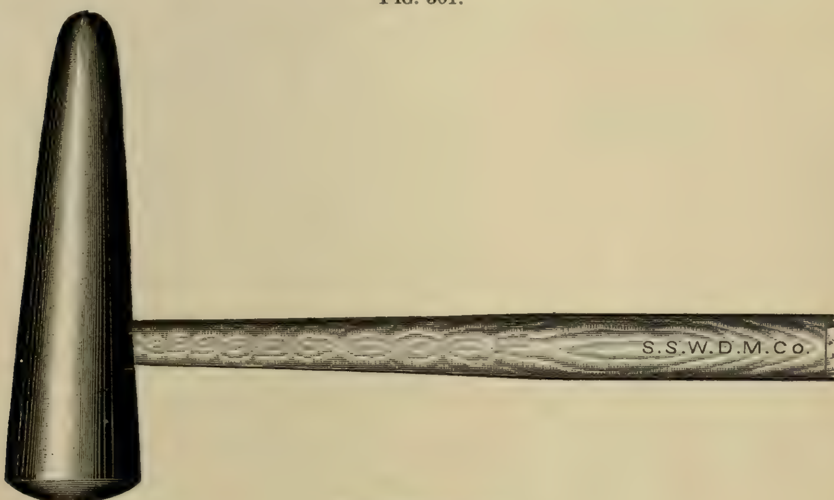
Plates for upper dentures which are to be retained by means of clasps are preferably made of two laminæ of No. 30 plate: their horseshoe form is an element of weakness, and a single lamina of plate when sufficiently rigid is too thick to be accurately adapted: however, through the use of a zinc counter-die a plate of No. 24 gauge may be well adapted; and this is the thickness to be employed when the operator prefers a single plate.

The same care is exercised in flattening these patterns as for partial lower plates. The results due to distortion of the pattern are not so great as with the lower plates, but are none the less annoying, and it may be serious.

Forming the Plates.—The poorer die is cleansed, assuming that the plate is one for a full upper denture, by brushing off any particles of sand or metal. The plate is laid upon a block of charcoal, and the broad flame of the blowpipe directed against it until it is a dull red: it is then plunged into water. The coating of oxide formed by this heating is permitted to remain, as it serves to prevent, in some measure, the intimate contact of the surface of the gold with the base metal of the die and counter-die. The tin pattern is laid upon the annealed plate, and its outline marked with a sharp point. The points of the pattern representing the anterior and posterior of the middle line of the vault are marked on the plate, which is then bent by the fingers along a line having these

points as extremities. It is then placed upon the die, its posterior edge carefully placed in position, and by means of blows delivered with the horn mallet the posterior part of the plate is driven into position : from this work forward, first along the median line, driving the plate into contact with the die at the deepest portions of the latter. As soon as the metal plate develops an increased elasticity, remove from the die, brush

FIG. 361.



Horn swaging mallet.

it free of any adherent particles of metal, and reanneal it ; then place on the die, and continue the malleting until a rough adaptation of the plate to the vault is secured. If the partial counter-dies have been made, the first of these is placed over the plate and struck three or four times with the heavy swaging hammer. Brush and reanneal the plate ; then, using the next counter-die, swage again. Now, while the palatal portion of the plate is held in position by the partial counter-die, the broad end of the horn mallet (Fig. 361) is employed to roughly form the alveolar portion of the plate.

The outer edge of the plate at this stage having a greater length than the plate outline marked along the model, it is evident that to adapt one to the other at least a portion of the surplus length must be cut out, or the plate must be so manipulated as to contract it along this line, or else the amount of surplus length will be represented by wrinkles in the plate. Some operators prefer removing from the portion of the plate at the frænum labialis a V-shaped section something less than enough to fully compensate for the increased length of the plate line. The writer prefers a method of manipulation which does not involve cutting the plate. It is difficult and somewhat tedious to prevent wrinkling by this method, but through the exercise of care, plates may be adapted to even marked alveolar under-cuts without wrinkling.

The plate is cut something larger than usual along this portion of its outline. When it has been adapted to the stage, and through the means described it is well annealed and placed in the counter-die, the die is

set in it, and one or two light blows are delivered with the swaging hammer on the die. The plate is again annealed; any wrinkles which have formed are removed by blows of the horn mallet; set in the counter-die, and again swaged lightly. Repeat the annealing, malleting, and swaging until all the wrinkles along the plate edge are but small irregularities and nowhere extend to the final plate outline. It is then annealed and swaged, using now heavy blows on the die, and turning the latter with the left hand, so that the blows are delivered above successive portions of the plate. The edge of the plate is now trimmed to near its true line.

Forming the Cap.—The cap piece is annealed and placed in position in the die, and fixed there by light malleting. The first of the partial counter-die is placed over it and swaged. The gold is annealed and swaged by the best counter-die. A pair of dividers, measuring the narrowest portion of the ledge of the cap, is passed around the chamber-piece, marking a ledge of uniform width; it is then trimmed along this outline, and finally its edge is given a long bevel from its upper surface.

Plate and cap are again annealed; the latter set in the second or finishing counter-die, and swaged. Removing the cap, the plate itself is placed in the counter-die, and it is again swaged.

Cutting Out the Chamber.—Midway between the lines representing the top and base of the vacuum chamber the plate is pierced by a plate punch. In this opening the blade of a plate saw, set to draw, not push cut, is placed, and then securely fastened in its frame. Rubbing the saw-blade with wax to make it cut more smoothly, the chamber is sawn out along a line a trifle above the base-line. The plate is now swaged, and then placed on the plaster model. The chamber outline is filed out, using a small smooth-cut half-round file for the purpose, until the line of junction between the base of the wax chamber and the model is just visible.

The cap piece and plate are again annealed, the former placed in position in the counter-die, and over it the plate, the die set over them, and then by several hard blows the swaging is completed. By means of sharp shears, using only their tips, the plate is trimmed to almost the outline marked on the model, and then a smooth file is used to complete the shaping; next an annealing, and then final swaging.

Testing the Adaptation.—The plate and cap are boiled in a 1 : 10 sulphuric-acid solution, washed, dried, and the plate tried on the model. The adaptation is tested by noting that the plate is in contact with the model throughout its upper edge, and that the edge of the chamber is in contact with the model. If zinc dies have been used, the posterior edge of the plate will be about one-sixteenth of an inch short of contact with the vault. If a Babbitt-metal finishing die have been used, this portion of the plate should be in contact with the vault. The uniformity of the contact is tested by pressure applied along the height of the ridge. Pressure at any point should not cause movement of the plate on the model. Next apply alternating pressure on the sides; if the adaptation be correct, there should be no rocking. Should the plate rock, the point upon which it appears to ride is noted. The cause of the fault, as a rule, will be found in the die, usually due to some prominence being bruised during the swaging, or it may be an inaccuracy due to imperfect mould-

ing. The plate is annealed: a thickness of pattern tin is placed over the faulty spot of the die, and the counter-die scraped out at the corresponding place. The plate is set in position on the die and swaged, then placed on the model, and again tested.

Should it be impossible to secure freedom from rock by this means, it is advisable to made a new die and counter-die, exercising the utmost care in moulding.

Attaching the Chamber-piece.—When the plate fits the model correctly the chamber-piece is set upon the former, and it is noted whether it is in perfect contact with the plate. The contact surfaces are cleansed by boiling in the sulphuric-acid solution, and then by scraping until they are bright. Borax is applied to the prepared surface, and the cap is clamped to the plate by means of two clamps made of No. 16 iron wire, shown in Fig. 362—one applied to either side of the chamber-piece flange, the other arms pressing the palatal surface of the plate. A small square of 18-carat solder is placed at the forward extremity of the chamber-piece, and the plate set upon a bed made of pieces of charcoal so distributed as to furnish a support to the entire plate. The broad flame of a blowpipe is rapidly passed around, beneath, and over the plate until the latter is heated to a cherry red, when a fine flame is directed against the plate near the solder until the latter begins to fuse, when the flame is thrown on the flange of the chamber-piece and the molten solder drawn beneath it. When the piece is cool, note whether the contact of the cap piece and the plate is perfect; if there be any separation—and separation of the surfaces is not unusual—the plate is reswaged. With the clamps in position four squares of solder are placed along the sides of the cap and one at its posterior edge, the plate heated, and the solder melted as the first piece; the fine flame is then passed rapidly around the chamber-piece until the solder flows freely, and upon examination is seen to fill the joint line at the palatal aspect of the plate. If the operation have been carefully done, the plate will have suffered no change of form, but should this latter have occurred reswaging is necessary.

Fig. 362.

The plate is boiled in the acid solution, washed, and dried. The edges are smoothed and rounded with No. 0 emery-paper, and its surfaces brightened with brush wheels and powdered pumice. It is now ready for trial in the mouth.

Swaging Rimmed Plates.—If the plate is to have its upper edge turned over to form a rim, the model has been prepared and dies made as described in Chapter X.

Additional care is necessary in manipulating the metal over the ridge in such plates. The annealing and light swaging are to be more frequent. After a moderately good adaptation is had, the plate is placed on the die, and by means of a brass chaser having a sharp wedge-shaped end about a quarter of an inch broad, the angle of the rim is clearly outlined, driving

the plate along this line into the angle by rapidly-delivered blows of a small, light hammer.

When swaging on the finishing die the plate is covered by a sheet of the cloth in which dental rubbers are enclosed. The cloth is wetted and laid over the plate, then covered by the counter-die and swaged. Without this adjunct it is frequently difficult to withdraw the plate from the counter-die without bending it. The same device is useful in swaging all plates which cling obstinately to the counter-die.

The plate edge is trimmed to the correct outline and smoothed.

Plates Without the Cut-out Chamber.—Plates are seldom made without the cut-out chamber unless designed as a basis for continuous-gum work or made of aluminum, for which there is no suitable solder.

It is a difficult but necessary task to so adapt the edges of the vacuum chamber that they shall fit perfectly to prevent the access of air to the chamber space. The plate is annealed frequently, and for the final swaging a zinc counter-die is advisable to drive the edge of the chamber into position. If this does not produce a sharp and distinct outline, a small brass chaser, driven by rapidly repeated blows of a small hammer, is employed to define the chamber edge. This is succeeded by a swaging with the zinc counter-die. Be careful that the edge of the chaser does not perforate the plate, and at the completion of the swaging examine the plate at the chamber edge for minute openings: should there be any, they are to be covered by a small piece of thin plate attached by means of solder.

In the making of swaged plates of aluminum select plate of about No. 24 gauge. In being reduced to plate from the ingot this metal appears to acquire its maximum toughness at this thickness; that is, as far as the swaging operation is concerned. Anneal the metal at as low a heat as possible—considerably below red heat. The finished plate is tougher if, instead of plunging it into cold water after heating, it be allowed to cool gradually. Covering its surface with oil and burning the latter off anneals the plate, and at a safe temperature, but a dirty discoloration difficult to remove remains. Over the face of the die spread a layer of tissue-paper and press the counter-die down upon it. Over the tissue-paper then set the annealed plate and press into the deeper portions of the vault. In working this metal it is preferable to have a series of partial counter-dies. The smallest of these is covered by a wet sheet of rubber muslin, and the plate is lightly swaged. It is reannealed and placed on the die, covered by the next sized counter-die, and again swaged. It is advisable to always have interposed between the plate surfaces and those of the die and counter-die enclosing it two layers—one of paper next to the die, another of muslin next to the counter-die—to prevent contamination of its surface by the base metals. The entire process of swaging should be gentle and gradual. The metal is very pliable and readily adapted; but, any sudden force tends to fracture it. Annealed at too high a temperature, it develops an increased liability to fracture. In giving the final finish to this metal use dry brushes; the wet polishing powders form upon its surface a black and tenacious scum.

Partial Plates.—Plates for partial dentures are of three varieties: first, those for the lower jaw; second, the two types used for the upper jaw, those retained by means of a vacuum chamber; and, third, those held in position by means of clasps attached to the natural teeth.

The first and last of these require special description by themselves. Partial upper plates, having vacuum chambers, are made after the same principle as any upper plate. The dies are made and prepared as described in the foregoing chapter. The tin pattern is to be made so that it represents an accurate copy of the future plate.

Fig. 363.

When flattened a duplicate is made of 18-carat gold plate of No. 26 gauge, and made about one-sixteenth of an inch or more larger, and giving a rounded outline to the portions about the necks of the teeth (Fig. 363).

When the plate has been annealed the tin pattern is laid on it and its outlines plainly marked. These lines serve as a guide in swaging, by keeping them opposite to and against the respective teeth.

The median line is noted as with the full plate; the gold, well annealed, is laid upon the die, from which the teeth have been cut, and malleted until the median line is represented in its proper position in the plate. The malleting is continued, alternating from side to side, until the gold becomes elastic; it is then reannealed and the malleting resumed.

Before any attempt at swaging proper is made the plate should be sufficiently adapted by the mallet to secure it against slipping from position. When this degree of adaptation is had, the plate is annealed and set in proper position in the counter-die, the die placed over it, and a few very light blows are struck. The die and counter are separated for assurance that the plate is in position. If it is not, or the plate is found to have moved, it is reannealed and further malleted, and again placed in the counter-die. When it is certain that it will not slip several heavy blows are struck with the swaging hammer, driving the plate well into position. It is removed from the die and boiled in pickle, then reannealed. A sharp point is passed around the plate, marking it plainly about one-sixteenth of an inch beyond the final line of the plate. By means of sharp-pointed shears, cutting with their points alone, by plate-nippers (Fig. 364), removing small portions at a time, and finally by half-round plate files, the plate is dressed out to the lines marked,

Fig. 364.

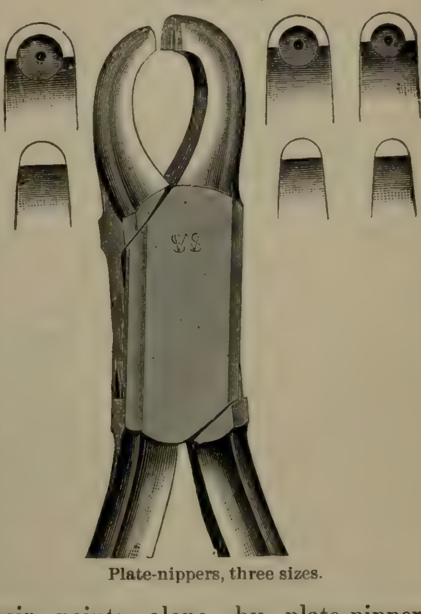


Plate-nippers, three sizes.

and no more. It is again placed in the counter-die and swaged heavily.

If the case be one having very deep and angular rugæ or a very deep vault, it is occasionally necessary to employ a zinc counter-die to drive the metal into the deepest parts.

The chamber is cut out as before described, the cap piece swaged, and next the plate and cap are swaged together, and the amount of trimming necessary to bring the edges of the plate to the outline marked on the model is noted. The surplus metal is to be removed by means of small half-round plate files of the finer cuts. The pieces are annealed and transferred to the finishing die, and swaged separately at first, and then together. After boiling in the sulphuric-acid solution, the plate is tried on the model. All of its edges should be in contact with the model, and correspond with the pencilled outline. It should respond to the same test as for any plate—immobility when any part is pressed upon. The chamber-piece is soldered in as described.

Strengthening Pieces.—If the case be one having an unusual distance between its posterior extremities, and which exhibits an undue weakness laterally, it is advisable to furnish additional support across these parts of the plate. The pattern for the chamber-piece has its basal angles continued to the posterior angles of the plate (see Fig. 358), and the pattern, uniformly enlarged, is duplicated in gold. Additional care is necessary in the first swaging of this piece that it should not alter position. It is fitted, trimmed, and bevelled as any chamber-piece, and then soldered in position.

Should the case exhibit breaks in its continuity which permit its ready bending, additional supports are required. Around isolated teeth crescents of plate No. 27 gauge about a quarter of an inch broad are swaged. The writer usually places these pieces upon the palatal surface of the plate, filing them to a feather edge before attaching them. Occasionally it is necessary, with plates bearing alone the posterior teeth, to place across the anterior weak segment, opposite the natural teeth, a stiffening piece. This is to be made of No. 29 plate; it is annealed, roughly swaged, and cut to a uniform width of about three-eighths of an inch or less. The plate and piece are cleansed and the posterior edge of the latter bevelled. A cream of borax is applied to the surfaces to be united, a minute piece of solder placed at a point of the anterior edge; then, heating first the body of the plate under the blowpipe, the solder is fused, and serves to hold the pieces in correct position. Transferred to the die, the two are well swaged. The extremities of the piece are held against the plate by means of two small clamps, two small squares of solder placed at the anterior edge, and the plate is heated until the solder flows between plate and teeth, filling the space perfectly; more solder is added if necessary, but never use an excess. The plate is now trimmed about the necks of the teeth, bevelling from the lingual side.

A neat finish is given about natural teeth and an effective strengthening piece furnished by partially encircling them with a piece of No. 16 gold wire which has been fitted and then flattened; this is attached to the plate by means of the minimum of solder.

At the sites of missing teeth the rounded tongues of plate upon which the artificial teeth are to rest are cut away, so that when the artificial

teeth are adjusted they shall hide the plate perfectly, and yet the tongues furnish adequate basal support. The edges of these tongues are to be given a long bevel. The other edges of the plate are to be rounded and smoothed.

Lower Plates.—Plates for lower dentures are preferably made of two laminæ of metal, using for the purpose No. 29. If made of a single piece, No. 24 gauge is to be employed. Much care is required in making and flattening the patterns for these plates, as any carelessness in these operations might alter the width or distance across the plate extremities, thus making accurate adaptation of the plate most difficult or impossible.

The plates are annealed: one is taken and pressed to the summit of the die by means of the fingers; the malleting is then begun at the middle of the labial aspect, continuing the malleting along the labial and buccal portions until there is a rough adaptation of this portion. Next mallet the lingual aspect until it assumes an approximately correct form, annealing as soon or as often as the piece develops elasticity. When malleted sufficiently to maintain its position on the die, it is transferred to the counter-die and swaged lightly; when assured that it will not slip from position in the counter-die, it is annealed and swaged well. The process is to be repeated with plate No. 2.

Both plates are now annealed and swaged together. One of the pieces is trimmed to almost the plate outline marked on the model, the other remaining untrimmed, forming a ledge between the plates which

Fig. 365.

Fig. 366.

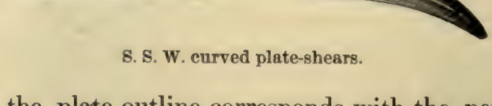
serves to hold the pieces of solder which are to unite the two. The plates are again annealed, and are separately swaged on the Babbitt-metal finishing die, and next swaged together, the untrimmed plate next to the die.

This latter piece is boiled in the sulphuric-acid solution and placed on the model. It should rest firmly upon the latter, exhibiting no movement when pressure is made upon any point of the plate. Should the alveolar ridge be unusually high, it is a useful expedient to roughly shape the plate along the groove by means of a tooth-brush handle used as a chaser, driving the middle line of the plate into a concave form, a grooved block of hard wood forming the piece into which the plate is driven. Plate-benders occasionally serve a useful purpose to the same end (Fig. 365).

When the larger plate fits the model perfectly, and the second plate is so closely adapted to the first that their point of union is almost imperceptible, they are in a condition to be soldered together. Both are boiled in the acid solution, and the surfaces to be united are well brushed and brightened by means of a coarse brush-wheel and pumice; they are washed, dried, and a coating of borax given the brightened surfaces. At the middle line, and on either side near the posterior extremities, wrappings of fine binding wire are placed, holding the plates firmly together (Fig. 366). Along the lingual border of the ledge squares of solder of the same fineness as the plates are placed, forming a continuous line of the pieces: no solder is placed on the labial and buccal portions of the ledge. The solder is to be drawn through from the lingual side, so as to furnish assurance of perfect union of the plates throughout.

The plate is laid on a bed made of small pieces of charcoal, and a blowpipe flame passed above it, not on it, until efflorescence of the borax ceases, when the broad flame is applied to the plate until it is heated to a uniform red, when the fine flame is directed against the solder pieces, fusing them one by one. As soon as the pieces have melted, a larger flame is thrown upon the labial and buccal aspects of the plate until these portions are at a higher temperature than the lingual ledge, the heat carried then forward until the entire mass of solder is seen to flow like water and appear at the labial and buccal portions of the joint, uniting the plates perfectly. When cold the binding wires are removed and the plate boiled in the acid solution. The ledge of the lower plate is trimmed away, using for this purpose the points of a very sharp pair of curved shears (Fig. 367). The trimming is completed by means of

FIG. 367.



S. S. W. curved plate-shears.

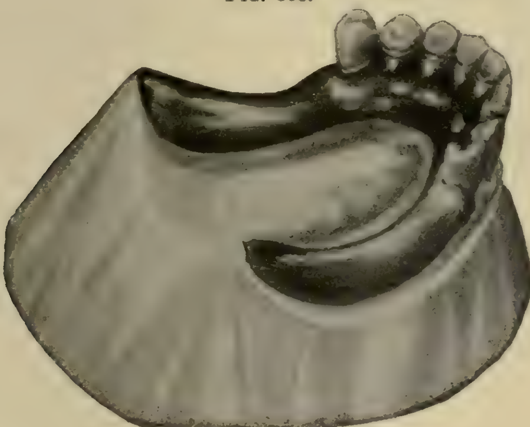
files, and when the plate outline corresponds with the pencil line on the model, its edges are rounded and smoothed with fine emery-paper.

Partial Lower Plates.—The most difficult class of plates to fit accurately and correctly are those for partial lower dentures. The operator's ingenuity and manipulative ability are taxed to provide in such cases acceptable substitutes for the lost organs: however, when these dentures are well made and adjusted they are among the most satisfactory of prosthetic appliances.

Except under very unusual circumstances, it is unwise to insert a lower piece, when no teeth but the second and third molars have been lost, the increased masticating surface thus provided rarely compensates for the inconvenience caused by the presence of a large plate.

Viewed as to the laboratory operation required in making the plates, the cases may be divided into two classes: First, those in which

FIG. 368.

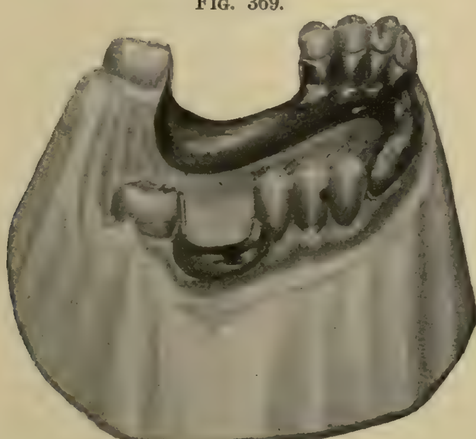


Partial lower plate, Class 1.

the natural teeth present are in one unbroken column; second, those in which the natural teeth are in broken column.

A typical case of the first class is most common of all, requiring a partial lower denture, six, eight, or ten of the anterior teeth remaining (Fig. 368).

FIG. 369.



Partial lower plate, Class 2.

The second is represented by cases having the cuspids and bicuspids of both sides remaining; the incisors and molars are to be replaced (Fig. 369).

The first requisite to success with this class of dentures is an accurate impression, always to be taken in plaster. In the degree that impression is difficult to secure by the use of plaster, the more imperative is the indication for the employment of that material.

The plaster model should have strengthening and guiding pins in all of its teeth ; the base should be broad and be given sloping walls.

Greater stability is secured by making these plates as large as possible compatible with the comfort of the wearer. The plate outline is marked at its lingual borders as deep as possible, without any impingement upon the tissues movable by the movements of the tongue, and to rest upon about one-half the lingual walls of the natural teeth. The labial and buccal edges are carried to a depth which shall afford a generous support to the artificial teeth, and be clear of impingement upon the soft tissue reflected from the cheek and lip.

FIG. 370.

To neutralize the tendency of these plates to bury the external border in the soft tissues their edge is to be elevated from one-sixteenth of an inch to one-eighth of an inch by placing a layer of wax of this thickness over that portion of the model. (See Chapter VIII.)

The dies and counter-dies are made as described in Chapter VIII. The finishing die is to be made of Babbitt metal, and is to be very heavy.

From the inferior die the zinc teeth are cut a trifle above the plate outline, and the angle between the lingual wall and tops of the teeth made acute, so that by bending the plate over the edges it is prevented from slipping during the operation of swaging.

The teeth to be clasped are cut almost level with their necks.

The plate, to assure accurate adaptation and to increase its rigidity, should be made of two laminæ, of No. 29 gauge. The completed piece should have sufficient rigidity to resist bending even when severely tried, so that an additional layer of material is necessary across the weak spaces, the lingual portions of the plate, which are back of the natural teeth. To ensure the required rigidity this supplementary piece is to be made of platinous gold of No. 27 gauge. A greater stiffness and better æsthetic effect are given if this piece be placed between, and not over, the two plates.

Much of the accuracy of the fit of the plate will depend upon the care with which the patterns are made. Heavy pattern material is used for this purpose, and adapted to the Babbitt-metal die so that it is an accurate representation of the future plate. Much care is necessary in flattening it, and the proper pattern is cut with greater surplus than usual with other classes of plates.

The pattern for the supplementary piece extends across all breaks in the plate continuity for about three-eighths of an inch beyond on both sides. It should be wide enough to extend from the necks of the natural teeth to the extreme lower edge of the plate.

Making the Plate.—The pieces are well annealed, and one is taken and bent roughly with the fingers. It is malleted into approximate adaptation at the middle of its lingual portion. Next the buccal sides

are malleted, and as soon as the plate becomes obdurate or exhibits a tendency to wrinkling it is reannealed and again malleted, the upper edge of the plate being bent over the cut surface of the zinc teeth. When it is approximately fitted by this means, and not before, the plate is placed in the counter-die, the die set over it, and tapped gently until it begins to settle into position. The die and counter are separated, and if the plate maintains its position, the die is replaced over it and a few moderately heavy blows struck with the swaging hammer.

Piece No. 2 is annealed and similarly manipulated. Both pieces are now boiled in the acid solution to remove the particles of base metal always adherent, and again annealed. Each in turn is placed between die and counter-die and swaged well. Usually it will be found that one piece has a greater surplus at its lingual border than the other, and it is set aside. The other plate is trimmed by means of sharp shears, plate-nippers, and files until it is within a trifling distance of the plate outlines marked on the model.

The supplementary piece of platinous gold is annealed at a high heat, and malleted to the die, reannealed and remalleted. It is next placed in position in the counter-die and swaged, again annealed, and again swaged. The extreme elasticity of this alloy necessitates that it should be annealed more frequently than ordinary plate. It is then trimmed to its proper size, and all of its edges except the inferior border bevelled. All of the pieces are annealed; the trimmed plate is set in the counter-die: within it is placed the stiffening strip, and over both the untrimmed plate, the die placed in position, and the three pieces swaged together. Removed from the counter-die, they are boiled in the acid and again annealed.

The untrimmed plate is placed in the finishing counter-die and swaged. It is partially trimmed at its upper border, so that it may be placed in position on the plaster model, which it should fit with the utmost accuracy. If it do not, it should be reannealed and reswaged. Any points of the plate interfering with its placement on the model are to be trimmed away.

Plate No. 2 is next placed in the finishing counter, and over it the strip of platinous gold; over both, the larger plate. The die is set in this, and by several heavy blows the swaging is completed. If there be any unusual difficulty in removing the pieces from the counter-die, the pieces bending in removal, they are to be reannealed and placed in position on the die and covered by a strip of the cloth enclosing dental rubber, which has been made perfectly pliable by soaking in water. The counter-die is set over this, and the swaging repeated. Upon separating die and counter, traction upon the cloth will withdraw the plates from the counter-die. The pieces are boiled in acid, and the surfaces to be united are cleansed perfectly by means of brushes and pumice, and well washed and dried. The strengthening piece is first united to the larger plate, that next to the model. A thin mixture of borax is applied to the surfaces of plate and piece which are to be united, and they are bound together by means of binding wire holding the extremities and middle of the supplementary piece. A small square of solder is placed at one edge, and the plate and piece are heated uniformly until the solder flows between them. If the platinous gold piece do not change form and separate at any edge from the plate, three more squares of solder are placed one at

the top, the others at the side joints, and are flowed between the pieces, uniting them perfectly. Boiled in acid, washed, and dried, the plate is now placed on the model; if it have undergone any change of form during the soldering, it is reswaged. If not, the surfaces of the two plates are now painted with a cream of borax, and firmly held together by means of three or four wrappings of binding wire. No borax should be present on the external portions of the plate. Along the ledge of the untrimmed plate, beneath the lower edge of the trimmed plate, a line of solder is placed, made of squares of about an eighth of an inch size. The plates are warmed until efflorescence of the borax ceases, and then a blowpipe flame is directed beneath the plate until both sections are heated to a bright red, when the solder will melt and flow freely between the plates and appear at the opposite edges. More solder is added at the same place if required, and it is melted and drawn between the plates until by its filling of all the joints it gives assurance that the plates are united throughout. It usually requires about a pennyweight of solder to perfectly unite the three pieces.

Remove the binding wires and boil the plate in acid. The lower plate is now trimmed to the outline of the previously dressed plates; the upper edges resting upon the natural teeth are bevelled lingually, the other edges rounded and smoothed. Bending the plate between the fingers is now a matter of difficulty. It is placed upon the model and should fit it perfectly.

As a rule, these plates are held in position in the mouth by means of clasps encircling two or more of the natural teeth. These will be described later in the chapter.

Clasp Plates for Upper Dentures.—Occasionally it is necessary that partial plates for the upper jaw be retained by means of clasps, instead of the vacuum chamber. These plates are usually given a horseshoe form, but it may be that smaller devices are at times applicable.

The first indication for the employment of this type of plate is such a configuration or peculiarity of the palatal vault that the vacuum chamber is inapplicable.

Another class of cases are those in which the patient objects strenuously to the presence of a plate of the size necessary when a vacuum chamber is used.

In rare instances the projecting chamber is a continued hindrance in enunciation, and the difficulty is remediable through the use of a small unprojecting plate.

Another class is found in cases in which artificial dentures mounted upon plates having vacuum chambers are displaced by the forces of mastication.

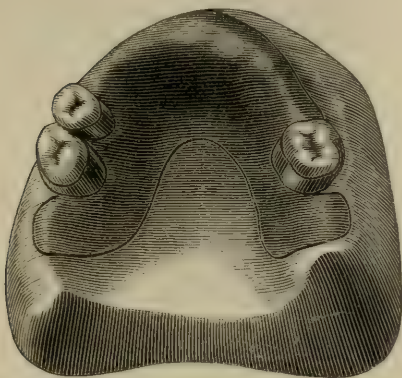
Other cases in which one or more teeth are to be replaced may be retained by a small plate held by clasps, where the chamber plate to be used would necessitate the wearing of a large piece.

Typical cases of the first class mentioned are found in those mouths presenting a large bony tuberosity occupying the height of the vault, one or more of the natural teeth absent, and deplacement is demanded.

The presence of a plate of the size required when a chamber is present may be productive of a continued nausea. Singers, actors, and orators

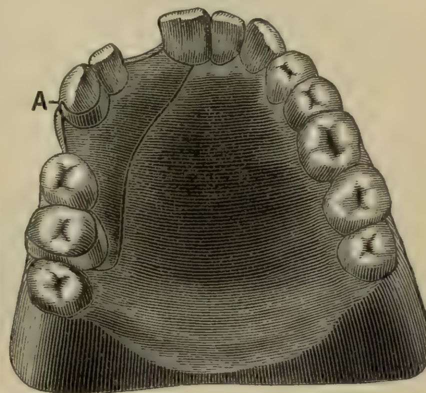
occasionally demand a fixture which shall be firmly held, and which shall not alter the form of the palatal vault.

FIG. 371.



Partial upper denture supported by remaining teeth.

FIG. 372.

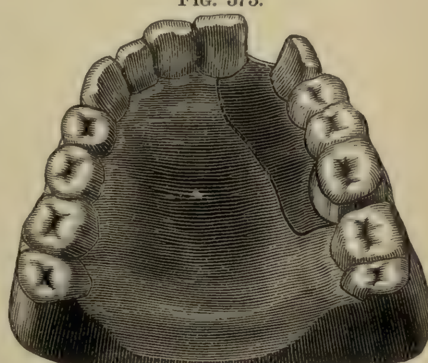


Badly-arranged clasp plate.

A typical case of the last class is one for the replacement of the incisors, the denture being displaced at every attempt at biting.

The plates are always more firmly held if the clasps are placed on both sides, so that the most usual form of these plates is that of a horseshoe (Fig. 371). This figure illustrates a typical clasp plate and the indication for this form of denture.

FIG. 373.



Supplemental clasp to relieve strain on molar tooth.

Figs. 372 and 373 illustrate the form of device obviating the necessity for the employment of an extensive plate.

It is determined, as described later, the several positions and forms of the clasps, the bases of which, as a rule, mark the posterior length of the plate. The latter is usually made to enclose an area of the vault extending rarely less, and as a rule more, than one-half of an inch from the necks of the teeth. The outline of the plate is marked on the model.

To ensure accurate adaptation and sufficient rigidity the plate is made of two laminæ of No. 30 plate. One of these is in swaging left larger than the other, so as to form a ledge upon which to place the solder used in uniting them. While soldering the plates are held together by means of the clamps used when attaching chamber-pieces, but when possible binding wire is to be preferred : the form of the plate, however, does not, as a rule, permit of this means of holding the plates together. After soldering the plate should be trimmed to fit closely about the necks of the natural teeth, but never to rest upon the teeth themselves. All

edges are next bevelled and smoothed: the posterior edge of the plate should be filed to a thin yet smooth edge, so that it shall not be readily perceptible to the tip of the tongue.

Cases present at intervals in which there is a loss of the bicuspids and two molars of one side, the solitary molar standing as a projection from a rounded tuberosity, and occupying the centre of the latter. The plate

FIG. 374.

form is given this outline (Fig. 374), the plate covering the tuberosity and perforated at the side of the molar. The tooth reproduced in the die is removed from one and permitted to remain on the other. The stump left by its removal is filed, giving it a square edge, so that it shall mark the outline in swaging. The section is sawn out, beginning in a perforation made with a plate-punch.

After swaging on the finishing die the perforation is filed away to expose the neck-line of the tooth.

In making plates for the class of cases described in Chapter VIII. those having loose teeth in the arch which are to be removed, and have a restoration by either artificial teeth or the crowns of the natural teeth themselves fitted to the plate, a plate support must be formed for the bases of the latter.

The impression taken and model made and prepared as described in Chapter VIII., the plate outline is marked along a line representing the labial or buccal line of the natural teeth. Dies are made and a plate swaged as for an ordinary case: if teeth are to be attached by means of soldered stay backings, the making of the plate and the mounting of the teeth do not differ from those operations for ordinary cases. Should it be designed to mount the crowns of the natural teeth upon the plate, supports must be provided for them.

Obviously, the only means by which this may be done is by attaching posts to the plate, over which the crowns are to be cemented. In the depressions which have been carved to represent the gum outlines which will exist as a consequence of the extraction of the teeth, marks are made to indicate the sites of the pulp-chambers of the teeth. The plate is to be made so that the base of the crown will rest upon it. This plate extension is to be perforated over each mark, and in the direction of the axes of the teeth when these latter shall be properly adapted. The openings are to be countersunk at their under surfaces. In each opening a platinous gold wire No. 16 is to be placed, tapered sufficiently to enter the opening, and be rigidly held in position by the plate.

The countersunk sides of the openings and the protruding tips of the posts are touched with the borax mixture; a small square of 18-carat

solder laid beside each post. The plate is heated from its upper sides: when at a uniform red heat a fine flame is directed against the plate at the base of each post, fusing and drawing through the solder.

The introduction of bridge-work has lessened to a great extent the employment of dentures mounted upon clasp plates. The substitution, although a wise procedure in many cases, in others is just as clearly contraindicated. It is undoubtedly true that the unilateral loss of teeth, leaving a space at the ends of which are teeth eminently suitable as abutments for the support of a bridge, finds the best prosthetic appliance in a bridge. In point of fact, bridge-work has even among conservative operators replaced most of the unilateral devices, but occasionally the use of plates for such cases is still found imperative. The introduction of the clasp of Dr. Bonwill (Fig. 375) gives an additional application of these small plates.

Fig. 375.

Clasps.—Clasps are metallic bands partially encircling the crowns of natural teeth, and serving as a means for the retention of artificial dentures. The employment of the device is prompted by necessity, and not by choice. With upper plates they are employed where the vacuum chamber is found to be insufficient to retain a denture in position, where the configuration of the vault renders the chamber inapplicable, or where the positions of the replaced teeth render the covering of the vault with a large plate unwarrantable. They are attached to partial lower dentures to prevent displacement by the movements of the tongue, cheeks, and lips, and by the forces to which these pieces are subjected during mastication.

The great advantage of the employment of clamps is an increased stability of the piece; the disadvantage is, if worn long enough they eventually cause the loss of the crown of the tooth clasped, through chemical solution, not mechanical abrasion. The food-deposits beneath and about the clasp are the seat of lactic fermentation, so that a gradual solution of the crown by lactic acid occurs if the clasps are not kept in an aseptic condition.

Not infrequently, the teeth are so mechanically strained by the force of mastication transmitted through the clasps that the retentive apparatus of the teeth succumbs and the teeth are dislodged. The latter is a more serious consideration than the loss of a crown: an artificial substitute for the latter may be provided, and serve for clasping; but loosened teeth are the *bête noir* of dentistry. This danger is lessened by accuracy of adaptation of the plate, and by having the clasps of sufficient elasticity to yield to stress and diminish the strain on the teeth.

Clasps properly adapted serve but to stay a plate, not to support it: the support should be derived from uniform pressure upon the soft tissues; the clasps are an adjunct preventing displacement. The violation of this principle is responsible for many of the ills attributed to the wearing of clasps.

In selecting teeth to be clasped, where a selection is possible, they should be chosen with a regard to their form, the position and condition of the tissues of the teeth, and the surrounding parts.

It is desirable that the clasps should not be exposed by the move-

ments of the lips, so that teeth posterior to the first bicuspid are preferably selected. To secure the best adaptation the walls of the teeth should be nearly parallel. Conical teeth, the base of the cone being at the necks of the teeth, are of improper form. A reversed relation, teeth much smaller at the necks than at their masticating surfaces, are also of disadvantageous form. Freedom from caries, firm fixation in their sockets, and no exposure of the cementum are desiderata, and where and when it is possible to secure these features they are to be regarded as essentials.

In the event of the absence of a latitude of choice certain precautions are to be observed. Carious cavities are to be perfectly filled and perfectly finished and the teeth to undergo periodical examination. Should there be any recession of the gum, exposing the cementum of the tooth, the clasp must embrace none but enamel surfaces. Exposure of cementum indicates loss of a portion of the retentive apparatus of the tooth, a relative lengthening of the crown, and hence an increased leverage upon the socket of the tooth; stress is lessened by making the clasp of thinner metal.

Clasping loose teeth always results in their loss, and is justifiable only under extremely rare circumstances, and then the clasp should be very light and elastic.

Clasps should be so adapted to the teeth upon which they are worn that there shall be no projections acting as sources of irritation to the tongue or cheeks. All of the edges should have a rounded bevel and be made perfectly smooth.

The length of a clasp is of two parts as to function—one, serving as the part of attachment to the plate; the other consists of one or two free ends which admit of form change, grasping the tooth and holding by the elasticity of the metal.

These free ends should have perfect elasticity, in so far as the property is present in the platinous gold alloy; they should permit sufficient yielding to allow the wing of the clasp to be carried over a tuberosity, and return to their original forms as soon as the stress is removed. The perfect elasticity is due in great part to the form of the clasps.

The strain upon the metal itself is at its narrowest part, so that if this part be at the point or slightly beyond the point of the attachment to the plate, the elasticity is markedly lessened and there is danger of breakage (Fig. 376).

FIG. 376. FIG. 377.

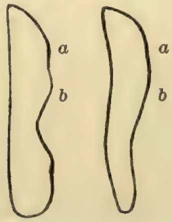


FIG. 376, clasp weakened by filing from lower edge.
FIG. 377, clasp properly shaped.

The maximum of elasticity is secured by having the greatest thickness of the metal at the angle, and diminishing its thickness toward the free extremity of the clasp (Fig. 377).

When a choice offers as to the passing a clasp with its body across the distal or mesial wall of a tooth, it is usual to place it on the distal wall as the better position to resist displacement of the denture, always provided the distal wall be not too short and inclined from the back.

The free ends of a clasp when possible are to be at the buccal aspect of the tooth.

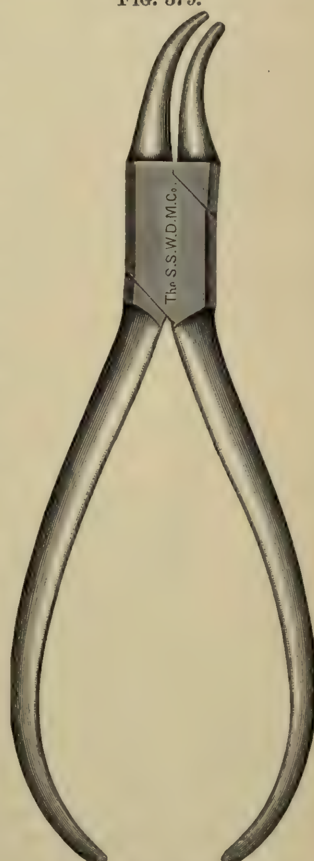
Greater stability is afforded by having a clasp embrace as much of

the enamel surface of a tooth as possible. Each individual case is a rule for itself as to the manner of placement of clasps. The operator by an examination of the teeth of the model and of a careful scrutiny of the natural organs determines the teeth which shall afford the best bases for clasps and secure the greatest stability to an artificial denture. Frequently it is necessary to modify the form and size of a plate according to necessities arising out of the enforced selection of clasp teeth.

Fig. 378.

The outlines of the future clasp are plainly marked on the plaster teeth by mean of a blue pencil. If the cementum of the tooth be exposed, the clasp is not to pass beyond the enamel border. At the side of the attachment to the plate it is made the section of a cylinder extending from just below the grinding surface of the tooth to the plate at its neck (Fig. 378). This form is frequently necessary with the clasps of partial lower dentures. For extremely short crowns the clasp is made of half-round platinous gold wire.

Fig. 379.



Curved pliers.

A pattern of the clasp is to be made of heavy pattern tin closely adapted to the plaster tooth and trimmed to correspond exactly with the pencil-marks. The external free ends of the clasps are plainly marked so as to distinguish each when flattened. They are flattened between the fingers. As a rule, the thickness of the metal should be greater with increase in the length of the free ends. Clasps are rarely made lighter than No. 26 gauge, and never heavier than No. 22. Wide clasps having comparatively short free ends, and which are subjected to light stress, are made of No. 26 ; those having long and narrow free ends are made of the heavier numbers. The average thickness is No. 25.

The patterns are reproduced in the clasp metal, the edges of the latter being filed to conform perfectly with those of the tin pattern.

Three pairs of pliers are usually sufficient to shape the various forms of clasps—a pair of four inch round-nose pliers to bend the clasp at its angles ; a pair of four inch flat-nose pliers, having sloping beaks—these to adapt the flat aspects of the clasp ; a pair of four inch round-nose pliers, bent to a curve of about one inch radius (Fig. 379)—these are used to make the clasp conform to rounded surfaces of the clasp tooth. Some operators prefer a special pair of pliers for this purpose—what are known as clasp-benders: the skilful mechanic usually finds them needless.

The metal is well annealed. Usually the bending is begun in the middle of the clasp, unless one extremity of the latter should be between two teeth, when that extremity is adapted first. Work from the middle toward either end, changing the pliers when necessary to make the clasp conform to the surface of the plaster tooth. When the clasp tooth has been accurately reproduced on the die, the clasp may be first bent to this and the fitting completed on the plaster tooth. It is a wise precaution to give the plaster teeth a coat of thin sandarac varnish before bending the clasps to them to prevent any abrasions of the surface of the plaster. When the clasp has been made to conform perfectly with the surface enclosed by the pencil-marks made on the plaster tooth, its edges are given a rounded bevel; they are smoothed with emery-cloth and buffed with pumice or a felt cone. The extremity or extremities which are not to be attached to the plate are bent away from the plaster tooth, so that the clasps may be readily withdrawn.

It is desirable that the axes of the clasp teeth be nearly or quite parallel. Should this not be the case, the cervix of one clasp must stand off from the neck of the tooth, so that the lingual walls of the several clasps are parallel. Violation of this precaution may render it impossible to withdraw the fixture from the model, when the clasps are cemented to the plate, without disturbing the mutual relations, or make it equally impossible to place the fixture in the position in the mouth when the clasps are attached to the plate with solder.

The plate is placed on the model, and one clasp set over its tooth: any points of the plate interfering with the placement of the clasp in its true position are to be filed away until the clasp is properly adjusted, and its junction with the plate is represented by a line. The plate is cut away in the same manner to permit the adjustment of the other clasp or clasps.

It is advisable to now attach the clasps very lightly to the plate, so that they are held by but one point, permitting the making of any changes in the form of the clasp which may be found necessary when the fixture is placed in the mouth. Occasionally the soft tissues of the mouth yield so much to the pressure of the plate that the same relations are not present between the pieces in the mouth as they were on the model; and if the attachment of the clasps to the plate be too extensive, there is no latitude for making the necessary changes in the pieces.

The clasps are fastened to the plate by means of adhesive wax made very hot: short sections of wire to extend at an angle from the top of the clasp to the plate are heated and laid in the cement. These prevent fracture of the latter in removal of the fixture from the model. When the cement is hard, the plate with the clasps attached is carefully lifted from the model, so that the cement attaching the clasps is not broken. About a couple of tablespoonsful of beach sand are placed in a plaster-bowl and just covered with water; plaster is dusted into this and stirred, making a thick batter, with which the plate and clasps are filled from the palatal side and nearly covered upon the lingual portion. When the investment is hard the cement is picked away, and a sharp-pointed scraper passed along the joints between clasps and plate to furnish a fresh surface for soldering. As but a small attachment is to be made at this time, all of the joint except one-eighth of an inch of its length is filled with a paste of whiting.

The point of soldering is made usually at the mesio-palatal angle. Borax is applied to this portion of the joint and a minute piece of plate laid over it. Two very small pieces of solder are covered with borax, and one laid on the plate, the other on the clasp above the joint. The mass is heated on a furnace, and then on a charcoal bed under the blowpipe until it is a uniform red, when a fine blowpipe flame directed on the plate just beyond the joint causes the solder to flow and attach the clasps to the plate. When cold the plate is boiled in acid and buffed, and is ready for trial in the mouth.

When the tissues of the arch and vault are softer than usual, their yielding alters the relations of the clasp and plate. When this softness is found to exist, it is advisable to test the adaptation of the pieces, both plate and clasp, before attaching the latter by means of solder. The plate, with the clasps cemented in position, is placed in the mouth; the plate is pressed into position, the clasps are pressed into apposition with the natural teeth. A small piece of sponge saturated with ice-water is then laid upon the wax until it is perfectly hard, when plate and clasps are removed, placed in an investment, and soldered.

Partial Clasps.—Any support which embraces less than two-thirds of the periphery of a crown may be fitly termed a partial clasp. Such appliances are designed mainly as braces. They are employed upon the palatal surfaces of bicuspids where no space exists through which a clasp may be carried, and where a plate, as for one tooth, may frequently be retained by bracing. Occasionally it is necessary to make the space between the teeth by means of a file, subsequently smoothing and polishing the cut surface of the tooth. Such mutilation is to be regarded as an unmixed evil and never to be practised unless absolutely necessary.

Placed upon bicuspids, these devices are usually made in pairs for the first and second bicuspids. The ends are to be made thin, so as to extend as far as possible between the teeth, the bodies of the pieces covering the palatal surfaces of the teeth (Fig. 381).

FIG. 380.

FIG. 381.

When the bicuspids and molars of the lower jaw are all lost, and the lingual wall of the cuspids sloping so that a large clasp covering it would prevent the plate from settling into position, a half clasp is applied, grasping the cervical half of the labial face (Fig. 380). The same device is applicable to the superior cuspids. The exposed ends of such clasps may be made to resemble gold fillings by filing the edges thin and soldering to them a layer of pure gold. A piece of the latter metal of No. 31 gauge is annealed and burnished over the clasp, the surfaces covered with borax, and united by means of 20-carat solder.

With small saddle plates, or partial lower plates which exhibit an undue tendency to bury themselves in and irritate the soft tissues, an inverted L made of half-inch round wire is soldered to the clasps, resting upon the grinding surfaces of the teeth. This device is particularly useful for partial lower dentures, when the third molars are remaining (Fig. 369), it being necessary to dress the plate away to permit placing

it in position, so that its posterior extremity is driven into the gum at every attempt at mastication. In such cases the L is frequently used without a clasp.

Dr. Bonwill has recently furnished a solution to a class of cases which heretofore has baffled the skill of the prosthetist. These are partial cases in which the axes of the natural teeth have been at such angles to one another as to make the adjustment of plate and clasps by ordinary means impossible. Such a case is illustrated in Fig. 385. The lingual cavity had the form of a frustum of a cone, the base of a cone the floor of the mouth, the top of the frustum the cutting edges of the teeth. The device necessary for this case would have been ineffective without the peculiar clasp support introduced by Dr. Bonwill.

When trimmed, it was found that the ordinary partial lower plate could not be adjusted to such a model, the distance between the edges of the teeth and their bases being so marked that it would be impossible to insert a plate in any other way than from without inward, thus virtually necessitating the plate support proper to be at the labial and buccal aspects of the ridge.

The plaster teeth were sawn half through, then broken off, leaving a sharp line of fracture, and all of them preserved.

Dies were then made; a brass plate swaged of sufficient size to support the teeth. Openings were made in the plate corresponding with the bases of the incisor and bicuspid.

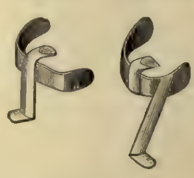
The plaster teeth were now cemented to place on the model.

The trial plate of brass was tried to the model, and cut away at all points interfering with its placement upon the ridge, and at the completion of this process had acquired the irregular form represented in Fig. 282; a saddle resting upon the alveolar ridge, and having two apertures much enlarged to permit passage over the isolated teeth at its extremities, dressed away to allow passing over the overhanging edges of left inferior second bicuspid and right inferior second molar.

The plate was reproduced in gold, using two laminæ of No. 29. This, when placed in the mouth, was found to have a lateral movement upon pressure, due to its lack of contact with the natural teeth.

FIG. 382.

FIG. 383. FIG. 384.



Ordinary clasps for such a case are out of the question, so on the molar and bicuspid partial clasps were made of the pattern suggested by Dr. Bonwill, having in the middle of each an inverted L resting upon the masticating surfaces of the teeth, and protecting against the extremities of the plate burying in the gum. The Ls were made of half-round platinous gold, the lower end extending to the plate and soldered to it, this extension serving as an elastic supporting-bar (Fig. 383).

The clasp upon the left bicuspid (Fig. 383) was arranged somewhat differently from the molar clasp in that its attachment to the L support was at almost its lingual extremity. This was done to increase the spring-like action of the clasp and enable it to pass easily to position without interfering with the perfection of its grip upon the tooth when the denture was finally in place.

Prior to attaching these clasps both apertures in the plate were surrounded by a heavy triangular gold wire, to prevent irritation by a thin edge at these places.

Plain teeth were fitted to the plate, backed and soldered, and along the external wall of the plate an artificial gum was made of the mixed rubber known as Walker's granular gum.

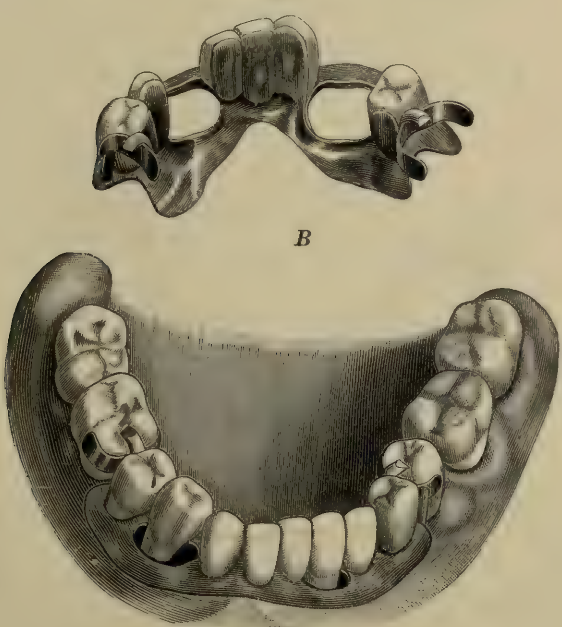
Fig. 385, *A*, represents the finished piece, and Fig. 385, *B*, the same in position upon the model.

The bars which attach plate and clasp are placed at the plate edge opposite to the overhanging wall of the tooth, so that the elasticity of the bar, while permitting the placing of the clasp over the overhanging wall,

Fig. 385.

A

B

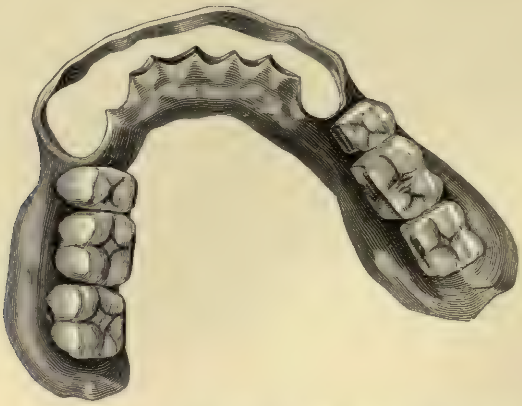


draws it close to the latter when the denture is in position. It was found necessary in the case illustrated to attach both clasps by posts placed at the disto-buccal angles of the plate. Dr. Bonwill applies the device with small saddle plates carrying one or two teeth when the clasp teeth are much inclined, and its application is eminently satisfactory.

A class of partial lower cases will be met with in which the dentures made for them have a tendency to slip from position backward. Clasps applied to the natural teeth but insufficiently overcome this tendency.

Prof. C. J. Essig has devised an adjunct to the plate which effectually overcomes this difficulty. In swaging the plate the anterior end of the buccal portion is carried farther forward than usual. A die and counter-die are made of the labial wall of the model, and two strips of metal are

Fig. 386.



swaged, one of No. 28 plate, the other of No 27 platinous gold, and made to fit this wall above the necks of the teeth. The pieces are soldered together, and their extremities are joined to the lengthened plate, the

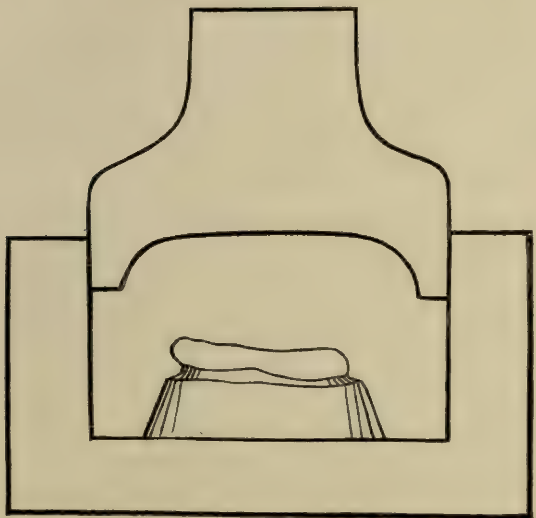
Fig. 387.

pieces invested and soldered. A modification of this idea, and suggested by it, is the device shown in Fig. 287. It is designed to lessen the strain upon the natural teeth due to the force of mastication acting at an unusual angle. It subserves its purpose perfectly.

Swaging with Shot.—An apparatus and method have been devised by Dr. Parker of Grand Rapids, Mich., through which the adaptation of a plate to a model may be secured with a greater degree of accuracy than attainable by swaging between dies and counter-dies. The apparatus consists of a heavy cast-iron cylinder having a thick bottom. The chamber of the cylinder is about four inches in diameter, large enough to freely admit the base of a large plaster model. The cylinder *A* is bored for the reception of a heavy plunger having a concave face, *B*; the plunger is turned to fit the cylinder. The plate is approximately adapted to the plaster model by means of dies and counter-dies. Fine bird shot is placed in the cylinder until it is filled to about an inch or more above

the alveolar edge of the model. The plunger is placed in position and its cylindrical head struck several times with a heavy hammer. The

FIG. 388.



pressure of the shot, evenly distributed over the entire plate area, drives the plate into accurate apposition with the plaster model. The plaster model itself is made to serve as a die. The plate is adapted by means of dies and counter-dies as closely as possible, when it is annealed, placed on the plaster model, and the swaging accomplished. The shape of the plunger is such that the shot about the labial and buccal walls of the plate is first compressed, supporting the model laterally; the succeeding pressure is upon the palatal portion of the plate, forcing it into accurate apposition with the model. The model, supported equally on all sides, is not fractured.

Electro-deposit Plates.—This variety of plate was designed to combine the advantages of a metallic plate with the accuracy of adaptation of those constructed of the vegetable bases.

Its method of making is thus described by Dr. C. S. Stockton: A plaster model is obtained, upon which reliefs, chamber, and rim outlining ridge are built of plaster. The model is boiled for a few minutes in wax or paraffin. The surface to be embraced by the plate is coated with plumbago. The model is immersed in a silver solution and connected with the battery as in any silver-plating operation: it is permitted to remain in the solution for four or five days, when it is withdrawn. The deposited silver is removed from the model, trimmed to the correct plate outlines, and polished. The surface to be covered by the vulcanite attachment is roughened. The plate is now immersed in the gold bath to deposit sufficient gold to permit of perfect vulcanization. The teeth are next attached by means of vulcanite, and the piece returned to the gold bath, where it is to remain until three or four pennyweights of gold are deposited. The principal objection to this form of plate is its tendency to tarnish, the gold plating not being impervious.

CHAPTER X.

THE "BITE" OR OCCLUSION.

BY GRANT MOLYNEAUX, D. D. S.

THE lower jaw forms, with the temporal bone, a joint called the "temporo-maxillary articulation." This joint is formed by the condyle of the lower jaw, which is of oblong form and is convex from side to side and antero-posteriorly, resting in a concavity of the temporal bone called the glenoid fossa. It permits of a hinge-like motion, a gliding motion, and a rotary motion, each of which is limited by the articular ligaments. The lower jaw is endowed with these movements to permit the proper incising and masticating of the food.

When all the teeth have been removed and artificial dentures are contemplated these movements become a matter of serious consideration to the dentist, as he is compelled to accurately locate the lower jaw in those positions and in the position of occlusion. The lower jaw has only one position of complete occlusion, and that is when both condyles are resting in the glenoid fossæ and the mouth is closed.

FIG. 389.

Skull showing temporo-maxillary articulation, and natural teeth in occlusion.

The position of the jaw is best studied from the skull (Fig. 389), which shows the temporo-maxillary articulation, *A*, and the teeth striking against each other. The teeth as shown in the cut are in the position of

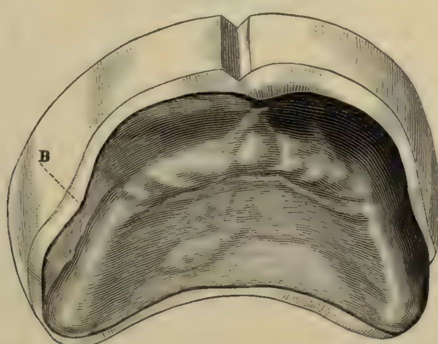
occlusion, and when the mouth is merely opened and closed without any lateral or forward motion it is called the motion of occlusion.

It is the motion of occlusion which it is so necessary to secure when about to construct an artificial denture, for, before we can arrange any of the artificial teeth we must obtain either the position of the teeth of the opposing jaw in occlusion, or, if there are no opposing teeth, the correct relation of the edentulous ridges.

The operation of obtaining the occlusion of the jaw is generally termed the "taking of the bite." The taking of the occlusion would seem to be a better term, but, as the former term has the sanction of long usage, is shorter, and is perfectly understood. The "taking of the bite," then, is simply obtaining the relation of the jaws in occlusion. This is best studied, by the beginner, from a patient with all of the teeth, upper and lower, *in situ.*

In its simplest form it consists of placing a roll of soft wax about as thick as the index finger between the teeth, and long enough to extend

FIG. 390.



Upper cast, with temporary base-plate in position.

from the last tooth on one side to the last tooth on the other, and have the patient bite into it.

The patient is directed to bite or close the teeth into the wax until the opposing teeth strike each other, and while holding them steadily in this position the soft wax is pressed close against the surfaces of all the teeth, care being taken to prevent the patient from changing the position of the lower jaw after the bite has been secured. The wax should then be chilled by a stream of cold water from a syringe to prevent bending, when the wax-bite can be easily removed.

This wax-bite will contain an impression of the upper teeth on one side and the lower teeth on the other. After this is accomplished an upper and lower impression of the teeth in the mouth should be taken.

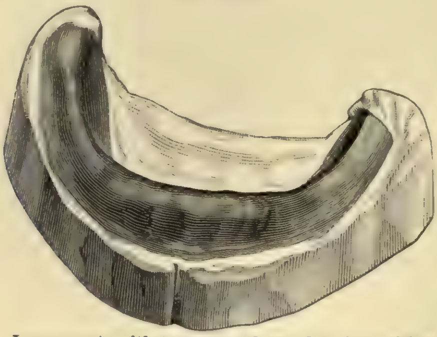
When these casts are recovered from the impression they are to be placed in their respective positions in the wax-bite, and fastened together by a wire or other means to permit of the wax being removed without changing the position of the casts.

If after the wax is removed the casts are found to bear the same relation to each other as the teeth in the mouth, the bite is correct.

Bites for Entire Artificial Dentures.—The first step in taking a

bite for entire dentures is to adjust to the casts, temporary base-plates. These base-plates are about three thirty-seconds of an inch in thickness, and are formed in sheets of either gutta-percha, beeswax, paraffin, or pattern tin. The kind usually employed is composed largely of paraffin, with a pink tint—" pink paraffin base-plates." A sheet of this is warmed

FIG. 391.



Lower cast, with temporary base-plate in position.

uniformly to soften it, when it is laid over the entire ridge of a lower cast (Fig. 391) and over the ridge and palatal portion of an upper cast, as illustrated in Fig. 390. In pressing these plates down upon the casts care must be taken not to reduce their thickness at any point by too great force, as they represent the thickness of the future permanent base, and any inequality of the permanent base would materially weaken it.

FIG. 392.

A

B

Showing the wax base-plates, temporary or trial plates, with bite-wax in position: *A*, upper bite-plate; *B*, lower bite-plate.

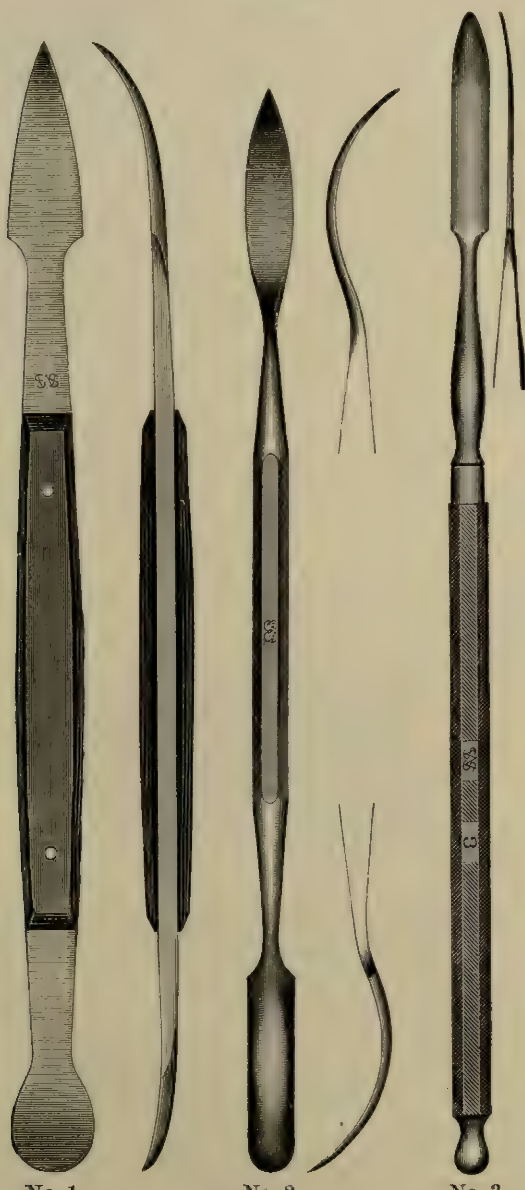
The edges of the wax-plate should now be trimmed to conform to the attachment of muscles on the ridge, which would make the upper plate higher in the incisive and cuspid region and over the tuberosities, and lower in the buccal region, as shown in Fig. 390, *B*. The lower wax-plate must be trimmed to rest easily on the ridge without impinging upon the muscles on either side of the ridge (Fig. 391).

A roll of soft beeswax is now placed upon the base-plate large enough to cover the entire ridge, about half an inch high and about three-fourths of an inch wide. This is pressed down upon the base-plate so that it will cover the labial and buccal side and extend an equal distance over the lingual side of the ridge, as shown in Fig. 392.

These plates are called "articulating plates," and after chilling them in cold water they are ready to try in the mouth. The upper plate is now placed in the mouth, and the length

of the lip marked by trimming the occluding surface of the bite-wax until it is the exact length of the upper lip, being careful when trimming to take off the wax, so that the occluding edge will repre-

Fig. 393.



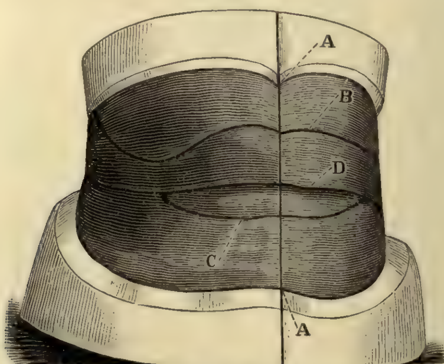
No. 1. No. 2. No. 3.

sent the exact plane of the cutting edges of the incisor teeth. The lower bite-plate is then placed in the mouth, and trimmed ante-

riorly to represent the desired length of the lower teeth. After the occluding surface of the bite-wax is trimmed to give the length of the teeth, the bite-plates should be returned to the cast, and if they have changed shape they should be again warmed and readapted to the casts, after which they should be cooled and returned to the mouth. The patient should then be instructed to gently close the mouth while the operator holds the plates in position on the ridges. It must now be carefully observed whether the occluding surfaces of the bite-wax strike uniformly against each other. If there is a space between them at any point, either the point which strikes must be trimmed off or wax must be added when required in order to have the blocks strike solidly against each other over the entire occluding surface. As the anterior part of the wax has been trimmed to give the length of the teeth, this should not be disturbed. If, however, the plates come together anteriorly and not posteriorly, wax should be added in order to prevent them tilting. After the operator has obtained an even contact between the bite-pieces when the patient's mouth is closed, he must "fix" the bite. This is accomplished by making two or three parallel cuts in the two waxes while in correct position; these cuts, together with one marking the central line, will serve as guides in maintaining their correct relation.

While this is being done the patient should be in a comfortable position, and no definite instruction given about closing the mouth, being directed to swallow and at the same time to close the mouth. The act of swallowing will involuntarily bring the lower jaw into

FIG. 394.



Wax-bite plates and casts in position: *A*, median line of face; *B*, high lip-line; *C*, low lip-line; *D*, occluding surfaces or lip-line.

the position of occlusion: the operator instructs the patient to bite hard until directed to relax. The softened edges of the wax are thus brought into such forcible occlusion that they cannot be separated, and the occlusion of the jaws, or the bite, is fixed. The wax-plates, upper and lower, may then be removed in one piece. The casts should be adjusted in the base-plates, and with a hot spatula the two bite-plates should be securely fastened to each other by melted wax, when they should be again cooled and returned to the mouth. At this point is determined the exact contour of the patient's face by adding wax to the labial surface of the bite-

wax, or by reducing the latter until the natural expression of the patient's face is restored.

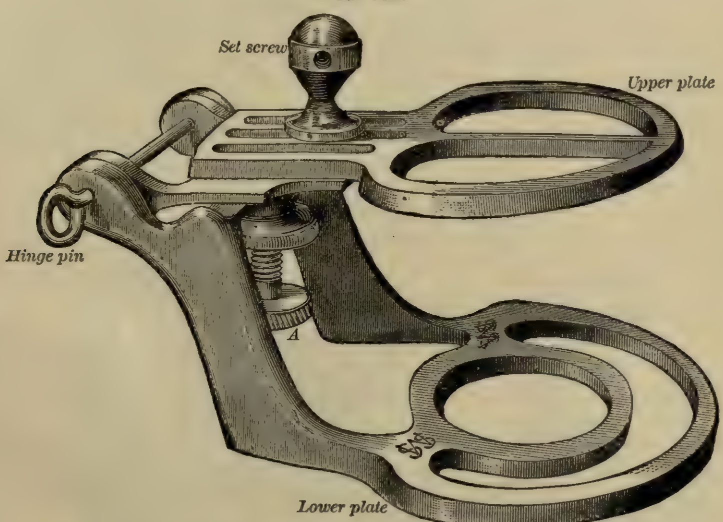
The next point to determine is the *high* and *low* lip-lines.

The occluding edges of the bite-plates represent the length of the lips at rest, as well as the length of the teeth. The high lip-line is the highest point of elevation of the upper lip, as when laughing; the low lip-line is the lowest point to which the lower lip is depressed. The next line is the median line of the face, which should be made on the wax perpendicular to the occluding surface of the wax-bite. These lines are marked on the wax with a sharp instrument, and are shown in Fig. 394.

The bite with all the markings is now removed, and the casts re-adjusted in their proper positions in the base-plates, when they should be fastened to the bite to prevent slipping, as represented in Fig. 394.

The Articulator.—The object of a bite is to secure the proper relation of the jaws for the arrangement of the teeth. Before arranging the teeth, means must be provided for maintaining the casts in their proper relation to each other when the wax-bite is removed. An instrument for this purpose is called an *articulator*, and is illustrated in Fig. 395. When such an instrument is not at hand, a *plaster articulator* can be arranged by extending the casts posteriorly, as illustrated in

Fig. 395.



S. S. White articulator.

Fig. 396. In the latter illustration the wax has been removed in order to show the relation of the upper and lower ridges, but before the wax has been removed, as in Fig. 394, the extension of plaster to form the articulator is poured around the base of the lower cast. After this has hardened soft plaster is poured around the base of the upper cast, allowing some to fall upon the posterior extension of the lower model. In Fig. 396 the position of the casts is shown within the heavy lines, while the plaster extension is shown above, below, and posterior to the lines.

The joint at *A* is to permit of separation when desired; the dovetail is to ensure a perfect readjustment of the two parts. This is the simplest form of articulator, and, though but little used, it is still of value.

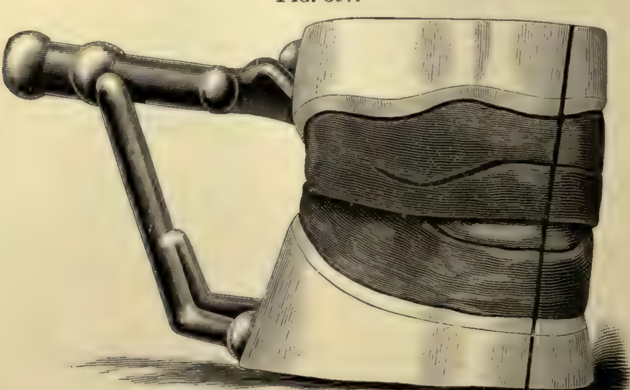
FIG. 396.

Showing plaster articulator with wax-bite removed.

The form of articulator in general use at the present time is illustrated in Fig. 395. It is made of brass, and consists of an upper and lower plate held together by a hinge pin. The upper plate is held at any desired point by a set-screw, and the upper and lower plates of the articulator are separated or lowered by the bite-screw, *A*.

In mounting cases in this instrument the cast and bite, as shown in Fig. 394, are placed between the two plates of the articulator, raising the upper part by the bite-screw, *A*, so that it will not quite touch the upper plaster cast.

FIG. 397.



Showing the plaster casts and bite mounted in the anatomical articulator.

The base of the casts should be trimmed to a perfectly horizontal plane, when a thin batter of plaster is mixed and poured over the lower part of the articulator, and the lower cast quickly placed in it, and the plaster brought up around the base of the cast to fasten it. The upper

cast is fastened in the same manner to the upper part of the articulator. When the plaster has hardened the bite-wax can be separated at the occluding surface and prepared for the arrangement of the teeth. In using this articulator it should always be observed that the bite-screw is opened a few threads to permit of bringing the casts nearer each other in case the bite was taken too long.

Anatomical Articulator.—This articulator is shown in Fig. 397, with the same models and bite as seen in Fig. 394 mounted in it. It is the invention of Dr. W. G. A. Bonwill. The inventor claims for it special advantages, which will be explained in the section on Articulation.

Bites for Full Upper or Lower Dentures.—To take a bite for a full upper or lower denture a base-plate and bite-wax are arranged after the manner just described, but in place of an opposing bite-plate of wax there would be the opposing teeth, upper or lower, as the case might be. The same rules for obtaining the length of the teeth, height of lip, median line, and contour are followed, but the wax-bite must be trimmed to allow each of the opposing teeth to strike it squarely. The bite-plate is now removed and the occluding surface warmed slightly, when it is returned to the mouth and the patient instructed to close against it. This will give an impression of the points of the opposing teeth in the occluding surface of the wax. It is now taken from the mouth and returned to the model, after which an impression of the opposing teeth should be taken and an articulating cast made.

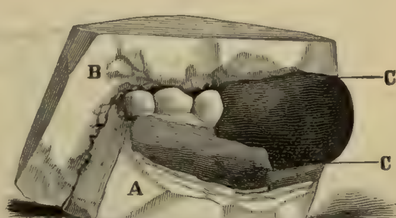
This cast, when recovered from the impression, is adjusted in the imprints of the teeth on the occluding surface of the bite-plate and fastened with melted wax.

The bite and two models are then mounted in the articulator after the manner described for entire dentures.

Bites for Partial Dentures.—Any artificial denture requiring less than the full complement of teeth is called a partial denture. If one or two natural teeth only remain, the bite is usually taken after the method just described, but openings should be made in the base-plate to allow the natural teeth to project (Fig. 405).

If the case is for one, two, or four artificial teeth, it is not always necessary to construct a base-plate. If two teeth—say a central and lateral incisor—be absent, a roll of soft wax should be placed over the space, and extend about the width of two teeth on either side. The patient may now bite into this, and after the wax has been pressed close against the teeth and subsequently cooled it may be removed and adjusted in the same position on the plaster cast.

Fig. 398.



Showing upper cast *A*, bite-wax *CC*, and lower antagonizing cast *B*.

After the wax is adjusted the cast should be filled to a level with the cutting edges of the plaster teeth with a roll of wet tissue-paper. A sheet of wet tissue-paper is now spread over this and the cutting edges of the plaster teeth, and as far forward as the wax. The wax-bite is

then filled in with thin plaster, which is allowed to flow on the cutting edges of the teeth, but not over the sides.

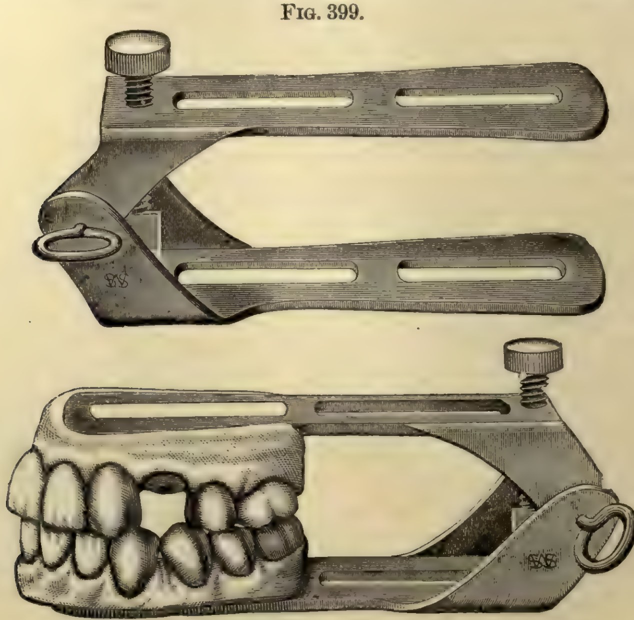
At the posterior extremity of the cast the plaster may be allowed to run down to a level with the base of the cast. The paper which has been previously spread over the plaster cast will prevent the two pieces from uniting. After the plaster has hardened the wax is softened in warm water and removed, when the bite and upper cast may be separated. (See Fig. 398. Bites for partial cases are described later, "New Bite-taking Means and Methods.")

Bites on a Permanent Base-plate.—Bites for Swaged Work.— Dentures constructed with a plastic base, such as vulcanite, celluloid, Watts' metal, cast aluminum, etc., require an arrangement of the teeth upon wax plates (temporary base-plates or trial plates). With swaged plates, such as gold, silver, platinum, etc., the bite is taken and the teeth arranged directly upon the permanent plate.

After the plate is swaged, properly trimmed, and wired (if a wire is necessary), a ridge of wax is placed directly upon the metal plate, and built up according to the instruction given in the first part of this chapter. The principles involved and the method employed for obtaining a bite with swaged work are the same as for vulcanite or celluloid, the only difference being in the use of the permanent metal plate instead of the wax trial plate.

Bites for Crown- and Bridge-work.—"Crown- and bridge-work" are methods of dental substitution which dispense with the usual forms

FIG. 399.



Showing the manner of mounting a crown or small "bridge."

of base-plates. Some forms of crowns are fitted directly to the root of the tooth in the mouth, no bite being necessary.

The form usually requiring a bite is known as the *ferrule* crown. In

this case the ferrule is first adjusted to the root, after which a roll of soft wax is placed over it and the adjoining teeth, and the opposing teeth are closed into it. After the wax is chilled it is slipped off and laid aside.

If the ferrule is detached from the root with the bite, it is recovered and readjusted to the root and a plaster impression is taken. The ferrule and post usually come away with the impression, and if not they must be removed from the tooth and placed in the impression and fastened in place.

The impression is then filled with a mixture of sand and plaster or marble-dust and plaster (plaster, 2 parts; sand or marble-dust, 1 part). After this cast has hardened the impression is broken off, the surplus plaster trimmed away, and the base made perfectly flat. The bite-wax is now adjusted to the cast, and the whole mounted in a crown articulator, as seen in Fig. 399, *B*.

Bites for small pieces of bridge-work, where there are only one or two spaces to be bridged over in connection with the abutments, are taken and mounted in essentially the same manner as for a single crown.

In extensive pieces of bridge-work the "true bite-plates" are exceedingly useful, though accurate bites in these cases may be obtained without the use of base-plates.

The method for using bite-plates and of mounting the bite in bridge-work is practically the same as for partial plates, the only difference being that the crowns or caps used as abutments for the bridge must be in position on the natural teeth before the bite is taken.

If it is desirable to have something more resistant than plaster antagonizing teeth to articulate in bridge-work, "modelling compound" may be used for the bite instead of wax.

Into the modelling compound bite a fusible metal, composed of 8 parts tin, 4 parts lead, 2 parts bismuth, and 2 parts cadmium, can be cast, thereby giving a metal antagonizing cast in place of one of plaster.

Difficulties encountered while Taking Bites.—By a careful examination of the temporo-maxillary articulation the student will observe that the lower law cannot close farther back than the position of occlusion. Therefore any movement of the jaw save that of the occluding motion must bring the condyles forward in the glenoid fossæ.

Fig. 400.

When a patient has lost all of the teeth from either jaw there is no fixed point of occlusion, and the patient may contract the habit of moving the jaw about to obtain different bearings on the edentulous ridges for the purpose of mastication. If this condition continues, it may become difficult to ascertain when the condyles are resting in the glenoid fossæ, and the patient is apt to protrude the jaw to one side or the other or directly forward, when the bite is being taken, and thus give a false occlusion.[1]

From the fact that the lower jaw cannot be drawn back farther than

[1] Under some conditions the shape and outlines of the articulating surfaces of the maxillary and temporal bones may undergo permanent alteration.—Ed.

the position of occlusion, any instruction given the patient, such as "bite back," or "close naturally," etc., will cause him to attempt to close in a certain way, and he will almost invariably close the wrong way.

There have been many suggestions as to how this tendency to protrusion can be overcome, but few of them seem to be of any real value.

The method which has been found most reliable in securing a correct closure is to instruct the patient to swallow, and just as the act of swallowing is complete have him bite firmly until told to relax.

When the patient has been for some years without teeth, even the above method fails and something more radical is necessary. A little apparatus, which was invented by Dr. Garretson of Iowa, has been satisfactorily employed in several cases, and is illustrated in Fig. 400.

It consists of two steel strips about 6 inches long, at one end of which are projections to enter the external ear, and a leather strap passing over the occiput which prevents the ear-pieces from slipping down. At the other ends of the metal strips is a chin plate which works on a ratchet, and which may be moved forward or backward as the case requires.

After placing the ear-pieces in position and tightening the straps, the chin plate is to be moved up firmly against the chin. The patient should now open and close the mouth repeatedly, and as the lower jaw is drawn backward the chin plate is moved upward until it is certain that the condyles are at rest in the glenoid fossæ. In this position the patient can open and close the mouth comfortably, but any attempt at protrusion will meet with resistance by the ear-lugs.

The bite-plates are then adjusted and the bite is taken as usual. Fig. 400 illustrates the application of the instrument.

The protrusive tendency is always increased by an excess of bite-wax and by failure to properly trim the wax base-plates.

Before attempting to take the bite the wax plates should be carefully trimmed to prevent them being forced off the ridges by the muscles of the lips and cheeks. The attachment of the buccinator muscle should be especially observed, for if there be any infringement upon this muscle every attempt to open the mouth will be accompanied by a displacement of the base-plates. The continual displacement of the base-plates causes uneasiness to the patient, and in his or her efforts to maintain the plates in position the lower jaw is forced forward. The bite-wax should also be trimmed to the smallest possible dimensions that will permit of obtaining the proper markings.

When the bite-plates are first inserted it is usual to find them in contact posteriorly when the mouth is closed, and there is a space between the occluding surfaces anteriorly. This indicates too great depth to the wax at the points of contact, and the wax is to be trimmed off until there is an even contact over the entire occluding surfaces.

It sometimes happens, however, that the plates strike anteriorly first, and if the cheeks are then drawn away with the finger and the occluding surface of the wax-bite observed, it will be found in perfect contact.

This is often deceptive, for there would frequently be a space between the plates posteriorly if they were held in contact with the ridges. The force of occlusion and striking anteriorly first caused a tilting at the heel, which would give the appearance of proper contact.

If dentures were constructed after such a bite, there would be considerable space between the opposing bicuspid and molar teeth when placed in the mouth, and contact only with the anterior teeth.

When the above condition occurs, it is well to hold the base-plates against the ridges firmly with the fingers, and then instruct the patient to close the mouth two or three times gently; the space can then be detected and the proper remedy applied.

Another annoying occurrence when taking a bite with base-plates of wax is the spreading of the base-plate under the force of occlusion.[1] This is more perceptible when taking a bite for a full upper denture with opposing natural teeth.

Some operators, instead of taking a bite for full upper dentures as described in this chapter, place a roll of soft wax on the occluding surface of the bite-plate, and have the patient close into this with his teeth, thereby taking the bite and an impression of the opposing teeth at the same time.

The warm wax, together with the heat of the mouth, causes a softening of the base-plate, and under the force of occlusion the latter spreads.

When the bite and base-plate are returned to the cast, it is found that the palatine portion of the base-plate is not in contact with the cast. The operator often attempts a readaptation of this part of the plate by pressing it down, and in doing so draws the impression of the occluding teeth nearer the centre of the mouth.

When the denture is finished the articulation of the artificial teeth with the natural is quite different from their arrangement on the articulator.

The deficiency may not be so great as to require a complete reconstruction of the denture, but the use of the corundum wheel will be necessary to partially correct it, whereas a little more time and care expended while taking the bite would have afforded more accurate results.

No matter how much time is spent in taking a bite with wax base-plates, there always follows a slight deficiency in the articulation.

It is impossible to so closely adapt wax or paraffin base-plates to the cast that there will not be some discrepancy between the model and the base-plates. When such is the case the position of the base-plate in the mouth may be slightly different from its position on the model.

This is another cause for the difference between the occlusion in the mouth and that of the articulator, and even in entire dentures the use of the corundum wheel is often necessary before precision of occlusion is obtained.

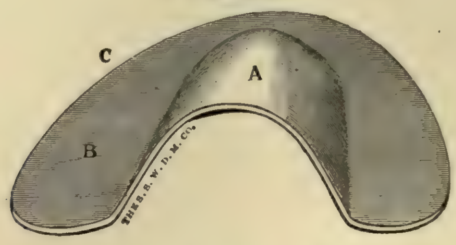
Dr. W. S. How described "New Bite-taking Means and Methods, with illustrations of the use of bite-plates," in the *Dental Cosmos* for Sept. and Oct., 1894, which the author deems of much value.

In Fig. 401 is seen an upper bite-plate of suitable thin metal, having a palatal portion *A*, a plane portion *B*, and a contoured edge or border *C*. When a full upper denture is contemplated, the bite is at once taken by placing on the bite-plate (Fig. 401) a sufficient quantity of warmed beeswax to secure a completely good impression, and at the

[1] To avoid this difficulty many operators prefer swaged temporary base-plates of the metal commonly used for the formation of chambers in vulcanite and celluloid work.—Ed.

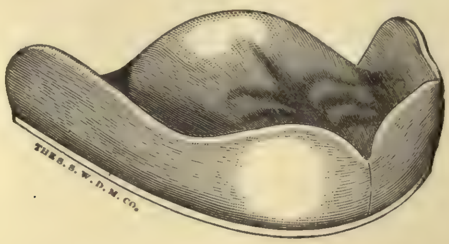
same time afford material for modelling the labial and buccal surfaces in a suitable manner to produce the proper facial expression.

FIG. 401.



The bite-plate here exhibits its novel and useful functions in enabling the operator to readily lengthen or shorten the bite, and also adapt the bite-plane *B* to the lip-line, as well as to the occluding lower teeth. When this has been carefully done and the mass removed from the mouth, the appearance will approximate that of Fig. 402. If the bite

FIG. 402.



then requires an increase of length, the bite-plate is held a moment over the Bunsen flame, when it will fall on a paper napkin held in the hand. It is then covered with a thin sheet of wax, replaced on the modelled wax, trimmed with the wax-knife along the contour border *C*, again put in the mouth, and comfortably remodelled and adjusted. The quickly transmitted heat of the metal bite-plate permits facile changes in occlusive adaptation and contour, without disturbance of the fit of the impression portion of the wax—an advantage of real consequence and value.

If upon further study it is desired to shorten the bite, the mass is removed from the mouth, the plate quickly warmed over the Bunsen flame, all replaced in the mouth, and the patient instructed to close the teeth firmly on the bite-plate, which, while accurately maintaining the plane of the occluding teeth to which it has been conformed, will at the same time cause the softer wax immediately in contact with the plate to gradually yield until the bite becomes suitably shortened.

In this connection it is important to note the functional difference of this metal bite-plate from the common wax plate, which yields and is indented by any considerable pressure of the occluding teeth ; whereas in the present instance so soon as the wax has cooled to a slight stiffness the patient is directed to press the teeth hard on the bite-plate (see Fig.

403), and the result is a bite-gauge identical in length with that which the finished denture will have under the ordinary pressure of the closed jaws. Many of the usual disappointing discrepancies between the common soft wax-bite gauges and the resulting defectively articulating dentures may now be avoided.

Fig. 403.

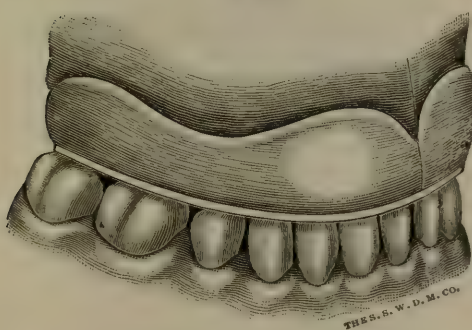
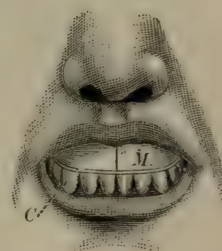


Fig. 404.



The smooth and hard surface of the bite-plane *B* fixes a constant and firm limit to the bite-length, while allowing the utmost freedom of lower-jaw movement in occlusion during the adjusting and modelling processes to secure a natural oral and facial expression, with a proper lip line, as indicated in Fig. 404. This having been accomplished, a roll of warmed wax is placed on the under side of the bite-plate, which is replaced in the mouth, and the patient while the previous process was going on having been instructed and practised in the correct manner of closing the jaw, the head being thrown back to bring the face horizontal and the jaw held as far back as possible, the teeth are pressed through the wax on to the bite-plate, and kept there while with the finger the labial and buccal portions of the soft wax are pressed in upon the natural teeth. The mass is then carefully removed from the mouth and kept in safe readiness for transfer to the plaster model when obtained from the plaster impression; and it is unnecessary to dwell upon the advantages of securing a certainly correct bite at the time of the sitting secured for taking the plaster impression. Fig. 403 shows a bite thus taken and transferred to the cast set in an articulator, and represents also the correct bite so obtained. This novel bite-plate provides for the taking of a very short bite. In fact, the bite-plane *B* may rest directly upon the gums, and the under teeth strike the plate, yet the rigidity of the metal plate is such that the wax impression and modelling will not warp in the adjusting, shaping, and removing manipulations; whereas by the old mere wax methods a trustworthy very short bite is often almost impossible.

For partial upper dentures sections of the bite-plate are with plate-nippers cut out as at *EE* (Fig. 405), and the bite taken in the way previously described.

The lower bite-plate (Fig. 406) is of like character with that of Fig. 401, the lingual portion *D* being designed to approximate the lingual conformation of the lower jaw, while the bite-plane *B* and contour

border C have the bite-taking functions of the upper bite-plate. For partial lower dentures sections may be cut out as at EEF (Fig. 405), to

Fig. 405.

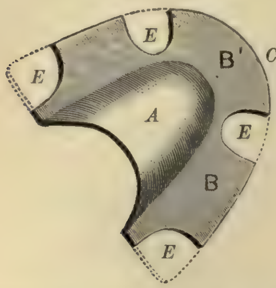
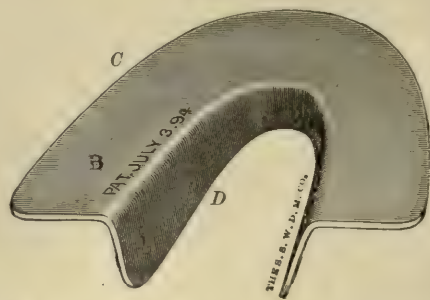


Fig. 406.



permit the passage of the remaining natural teeth through the bite-plate, the intermediate planes of which can be shaped to conform to any plane of the occluding upper tooth or teeth.

The Separation of Bites.—After the plaster which fastens the bite to the articulator has hardened the bite should be separated at the occluding surface. This is accomplished in entire cases by passing a heated spatula or thin knife-blade between the occluding surfaces, when they will readily part.

To separate partial cases or full upper or lower cases where there are opposing plaster teeth, the bite-wax containing the plaster antagonizing teeth is to be warmed until the bite-wax is softened throughout. The models may then be readily separated and all surplus wax removed.

Articulation.

The articulation of the teeth is one of the most important steps in the process of constructing an artificial denture.

By the term "articulation" is meant the placing or an arrangement of the artificial teeth upon base-plates, so that they will appear like, and perform as nearly as possible the functions of, the natural teeth for which they are a substitute.

It has been often observed that under most conditions the more closely is followed the normal arrangement or articulation of the natural teeth the greater will be the utility of the artificial.

Therefore, it is of first importance for the student to study the teeth, their names, forms, arrangement, and requirements, in order to apply the principles in constructing an artificial denture.

Names, Shape, Surfaces, and Position of Teeth.—The permanent teeth are thirty-two in number, sixteen in either jaw, divided as follows:

	Central incisors.	Lateral incisors.	Cuspids.	Bicuspids.	Molars.
Upper or Superior.	2	2	2	4	6
Lower or Inferior.	2	2	2	4	6
	Central incisors.	Lateral incisors.	Cuspids.	Bicuspids.	Molars.

The arrangement is bilaterally symmetrical.

Taking a perpendicular line through the centre of the face, it should fall between the central incisor teeth superior and inferior.

Beginning at this line and counting either way, we have in order—first, the central incisor; second, the lateral incisor; third, cuspid; fourth, first bicuspid; fifth, second bicuspid; sixth, first molar; seventh, second molar; eighth, third molar.

For the purposes of an artificial denture twenty-eight teeth are found sufficient, the third molars being omitted (Fig. 407).

FIG. 407.

Upper and lower plain teeth in sets of twenty-eight.

Each tooth has five surfaces, as follows:

1. Labial surface, next the lips or
   Buccal surface, next the cheeks.
2. Incisal surface, cutting edge of the incisor teeth, or
   Occlusal surface, cutting or grinding surface of the bicuspids and molars.
3. Mesial surface, the proximal surface directed toward the median line of the face.
4. Distal surface, the proximal surface directed away from the median line of the face.
5. Lingual surface, next the tongue.

Mesial, distal, and lingual surfaces are common to all the teeth, whether upper or lower.

The line of junction between the crown and root of a tooth is called the cervical portion, or "neck," of the tooth, and is usually at the gum margin.

In dental prosthesis there is use for only the crowns of teeth, and, as artificial crowns are made so nearly like the natural in outward appearance, it is deemed advisable to use them in the further illustration of this subject.

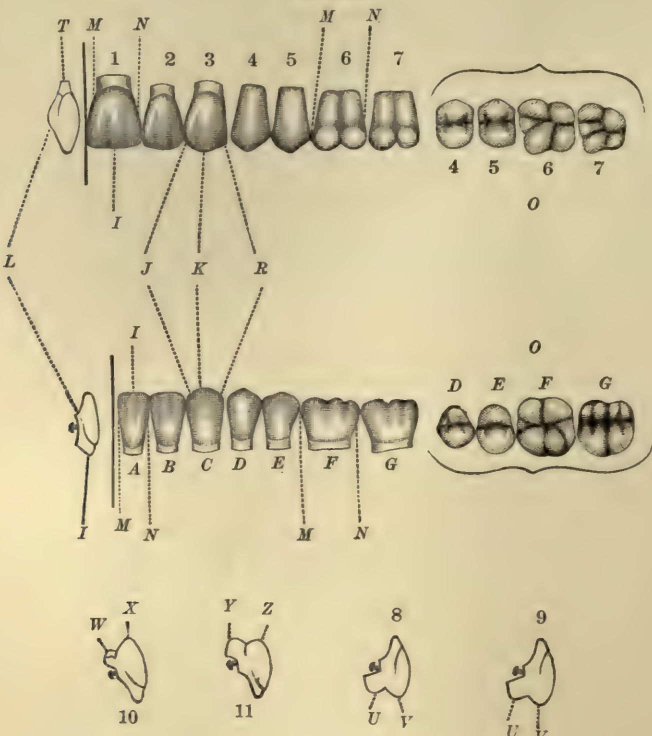
DIFFERENTIATION OF THE TEETH.

Upper Teeth.—In Fig. 408 are represented the half of an upper and a lower set of teeth for the same mouth, showing the labial and buccal surfaces 1 to 7 and *a* to *G*, and the occlusal surfaces of the bicuspids and molars, *O*. The perpendicular line represents the median line of the face. No. 1 is the left superior central incisor. It is recognized

as a "broad, wedge-shaped tooth, and is the largest of this style in the mouth."

No. 2 represents the superior lateral incisor of the same general form, but smaller. The side to which these teeth belong is determined by looking at the labial surface and placing the longer mesial surface *M*

FIG. 408.



toward the median line. Also, the more acute angle, where the mesial surface *M* joins the incisal surface *I*, points toward the median line of the face. *N* is the distal surface of the central, and points toward the mesial surface of the lateral incisor.

No. 3 is the cuspid, so called from its having a "pointed projection or cusp on the cutting edge." The labial surface of this tooth is convex, while that of the incisors is flattened. The cusp has a long and a short cutting edge. *K* marks the point of the cusp, *J* the shorter anterior cutting edge, and *R* the distal and longer cutting edge. The mesial surface points toward the distal surface of the lateral incisor. Placing the longer proximal surface and the shorter cutting edge of the cusp toward the median line determines to which side the tooth belongs.

Nos. 4 and 5 show the buccal surfaces of the first and second bicuspid teeth, which so nearly resemble the labial surface of the cuspid, except they are smaller, that no further description of these surfaces is necessary. In addition to the labial cusp these teeth have a lingual cusp, shown in

vertical section Nos. 8 and 9, *U*. The lingual cusp is usually a little shorter than the buccal cusp *V*, and not so pointed.

The superior molars are the grinding teeth, and have "broad occluding surfaces, possessing four cusps," Nos. 6 and 7, *O*, the two anterior or mesial cusps being heavier and longer than the two distal cusps, while the mesio-buccal angle is the most acute. Directing the broader proximal surface, while looking at the buccal surface, toward the median line of the face, will determine to which side the tooth belongs.

The second molar 7 very nearly resembles the first molar, except being a little smaller.

Lower Teeth.—While the superior central incisor is the largest wedge-shaped tooth in the mouth, the inferior central incisor is the smallest, and is shown in *A*. It has the same general formation as the superior central, but is longer in proportion to breadth.

The inferior lateral incisor *B* is a little broader than the inferior central, and the crown is usually a little shorter.

The inferior cuspid *C* bears a close resemblance to the superior cuspid, but is longer in proportion to breadth.

The first inferior bicuspid *D* resembles the inferior cuspid in form more than a bicuspid, but, owing to its extreme narrowness, it would never be mistaken for a cuspid. It very seldom possesses more than a diminutive lingual cusp, as shown in Fig. 408, *W*, and is much narrower than the second bicuspid inferior. Bicuspid, second inferior, is broader than the first bicuspid, and in proportion to length is broader than the upper bicuspids. The principal distinguishing feature of this tooth is its lingual cusp, No. 11, *Y*, which is usually more acute than the buccal cusp *Z*, and quite as long; the lingual cusp is divided into two distinct sections, mesial and distal. The lingual surface is quite as broad as the buccal.

Molar, first inferior, is the largest tooth in the lower jaw, is "trapezoidal in form, has five cusps," three buccal and two lingual, *F* and *O*, the lingual cusps beings usually quite as long, and often a little longer than the buccal cusps. The upper molar is more rhombic in form, and has four cusps, the two lingual being slightly shorter.[1] The side to which it belongs is determined by the same rule as with the upper molars.

Molar, second inferior, has the general shape of the first, but is smaller and possesses but four cusps, *G* and *O*.

The same rules are applied for determining the side of the mouth to which the lower teeth belong as with the upper. A careful study of the anatomy of the natural teeth, as found in Black's *Dental Anatomy*, where the foregoing facts are treated more elaborately than is admissible in a chapter of this character, will be of great service to the student of prosthetic dentistry.

Artificial Teeth.

Artificial teeth are divided into two general classes—viz. gum teeth and plain teeth.

[1] Observation has shown that when the lingual cusps of lower molars are longer than the buccal (of natural teeth) there is a corresponding diminution in the length of the lingual cusps of upper molars, these being just as much shorter than their buccal as the lingual cusps of molars are longer than their buccal cusps.

These are again subdivided into several varieties, as follows (see Figs. 409–417):


FIG. 409.


FIG. 410.

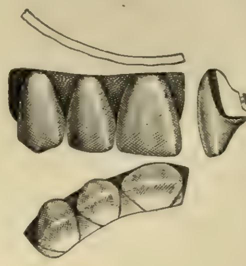


FIG. 411.


FIG. 412.


FIG. 413.


FIG. 414.

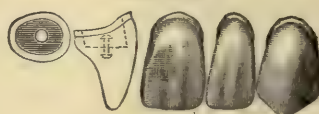


FIG. 415.


FIG. 416.

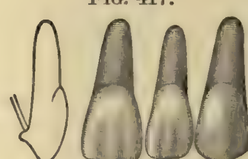


FIG. 417.

Gum Teeth.	Single gum teeth, Fig. 409. Gum sections, Fig. 410. Festooned gum sections, Fig. 411. Gum teeth for metal plates (gum plate-teeth), Fig. 412.
Plain Teeth.	Are always single, Figs. 413, 414, 415, 416, 417. For mental plates (plain plate-teeth), Fig. 416. For vulcanite plates, Figs. 413, 414. For celluloid plates, Figs. 413, 414. For continuous-gum plates, Fig. 417. Countersunk-pin teeth, Fig. 415.

The teeth are again divided into "long bite" and "short bite," common to both gum and plain teeth.

While the labial and proximal surfaces of artificial teeth resemble the natural organs, the lingual side is adapted for attachment to the base-plate of the denture. In this side two or more platinum pins are arranged, the position of which determines the length of the bite, whether long or

short, and is a very important matter to consider in making a proper selection.

In addition to the divisions of artificial teeth already given, there are—

Teeth with headed pins, Figs. 410, 413, 414, 415, for plastic bases.

Teeth with straight pins, Figs. 412, 416, for plate work.

Teeth with pins lengthwise, Figs. 412, 416.

Teeth with pins crosswise, Figs. 413, 414.

Pins lengthwise are arranged in series with the long diameter of the tooth, or with one pin near the cutting edge and the other nearer the neck of the tooth.

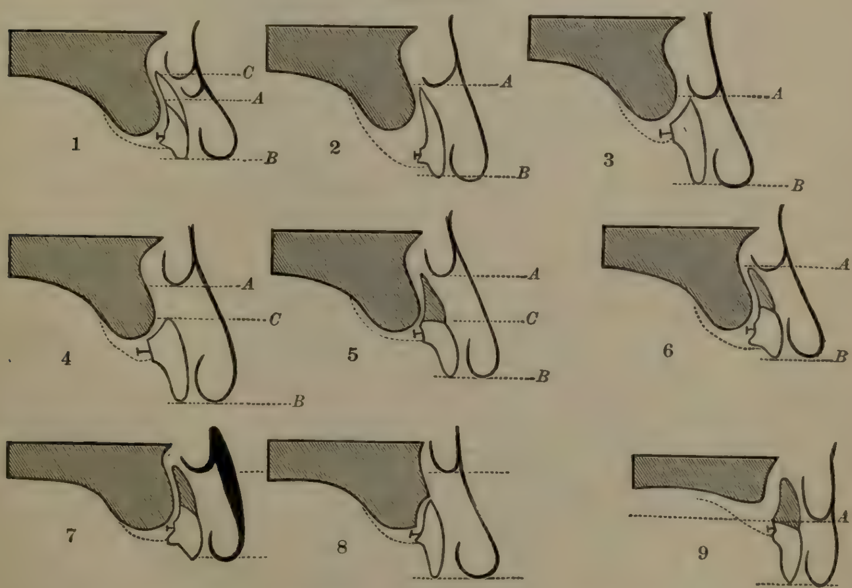
Pins crosswise are arranged in parallel across the shorter diameter of the tooth. Short-bite teeth usually have the pins arranged crosswise, as have also gum-section teeth, while in plain teeth the pins are arranged either way.

Rules for Selecting Teeth.

In making a selection of gum or plain teeth, long- or "short-bite" teeth, some rules should be adopted on which to base our choice.

By referring to Fig. 418, No. 1, we see represented a vertical section of the ridge at the median line, showing the position of the upper

Fig. 418.



lip *B* at rest, and the same at *C* elevated to its highest point, as in laughing. The space between *C* and *B* must either be filled in with a plain tooth or gum section. If the distance between *C* and *B* would not require a tooth too long for the proper appearance, a plain tooth would be suggested, as is seen in the figure.

The second point to be observed in this same case is the "bite" of the tooth. In the illustration we find the pins on the lingual side nearer

the cutting edge, and the major portion of the tooth extends above the pins; and it is at once recognized as a short-bite tooth. It is obvious that a tooth with a longer cutting edge could not be used, because it would project too far below the lip line, *B*, and would expose too much tooth. Again, if the tooth did not extend as high as *A*, the base of the denture would be exposed and an unsightly appliance would be the result.

Rule.—A long ridge and short lip suggests the use of short-bite teeth.

No. 2 illustrates a case where a plain tooth is indicated, but where a short-bite tooth is contraindicated. The lip *B* is longer and the elevation, *A*, not so great as in No. 1.

As for appearance, a short bite-tooth could be used, but by removing the pins so far from the ridge in order to bring the cutting edge of the tooth to the lip line *B* an unusual thickness of the plate is occasioned, which would be a serious impediment to the tongue in speaking. Therefore we must use a tooth with the pins nearer the cervical extremity, and with the major portion of the tooth between the pins and cutting edge. This tooth will be recognized as a long-bite tooth, and is illustrated in No. 3. It will be seen that the ridge lap is shorter than in No. 1, for the reason that it is not necessary for the tooth to extend beyond the high lip line *A*.

This character of tooth gives more room for the tongue, and also allows the lower teeth the normal under bite.

Rule.—A short ridge and long lip usually indicate long-bite teeth.

No. 4 illustrates a case where a plain tooth is contraindicated, but where a long-bite tooth is indicated. The lip line is the same as in No. 3, but it will be noticed that the high lip line is considerably elevated, and is as much higher than No. 3 as from *C* to *A* in No. 4. It is evident that the space from *A* to *B* must be filled in, either with a tooth or a tooth with porcelain gum, but in this case the distance from *A* to *B* would give a tooth of too great length for a natural appearance. Therefore we must select a gum section that will give a tooth of the proper dimensions, but with a porcelain gum extension that will reach *A*, as shown in No. 5 (known as long-bite gum tooth).

Rule.—Where the distance between the *lip line* and *high lip line* would require a tooth of too great length for proper appearance, a "gum tooth" is indicated.

In No. 5 the length of tooth is shown to extend from *B* to *C*, and the extension above *C* to *A* is of porcelain, in order to hide the unnatural base of the denture.

No. 6 illustrates the use of a short-bite gum tooth. This figure is the same as No. 1, except the high lip line is at *A* instead of *C*. It will be noticed now that the distance between *A* and *B* would require a tooth too long for a good appearance, as shown in No. 1, *A* to *B*; consequently we must reduce the size of the tooth and add a porcelain gum, as seen in No. 6.

No. 7 illustrates a case where a gum tooth is contraindicated. Owing to the excessive fulness of the alveolar ridge, the use of a gum tooth would cause an unnatural protrusion to the upper lip, and, if the same method were followed in the construction of a denture in this case as in the preceding illustration, a plain tooth would also be contraindicated.

In this case, however, a plain tooth is indicated in order to prevent disfigurement of the face, but an entirely different method of arrangement, as illustrated in No. 8.

The six or eight anterior teeth must be arranged to rest with their necks slightly imbedded in the gum-tissue covering of the ridge.

In order to accomplish this the gum lap must be ground thin, and where this strikes the plaster cast the latter must be trimmed away slightly, as shown in No. 8.

When the denture is inserted the front teeth press into the gum-tissue gently and hide the cervical portion of the teeth, thus affording a very close imitation of the natural organs.

No. 8 also illustrates another character of tooth—viz. a medium bite, the pins being arranged near the centre of the tooth.

The same arrangement of teeth is necessary for No. 7, *A*, No. 8, except that a short-bite tooth is suggested.

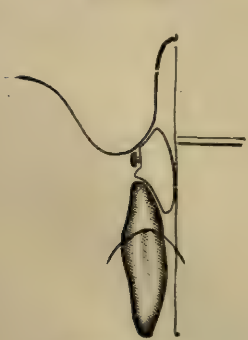
No. 9 illustrates a case of almost complete resorption of the ridge. In this case a plain tooth could be used, but, owing to the considerable amount of vulcanite necessary to restore the features, and the danger of not obtaining a good adaptation when so much vulcanite is used, it is better to use a thick gum section in order to reduce the quantity of vulcanite.

Therefore, as a rule with vulcanite base in cases of great resorption of ridge a thick gum section is indicated.

With a close study of the foregoing illustrations, and the following chart[1] the student should be able to enter upon the study of the more artistic features of the subject.

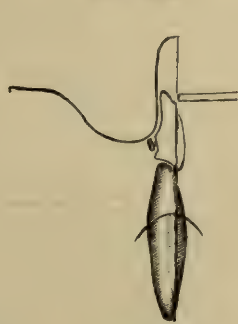
Definition and Illustration of Terms employed to Express Varieties of Styles of Teeth.—Figs. 419–426. *Short or Long Ridge Lap.*—The form of the heel or butt of the tooth. *Short or Long Shut.*

FIG. 419.



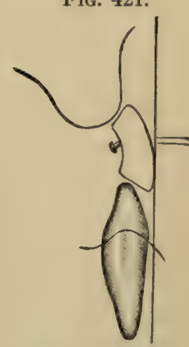
Short ridge lap.
Long shut.
Long bite.

FIG. 420.



Long ridge lap.
Short shut.
Short bite.

FIG. 421.



Short ridge lap.
Long shut.
Short bite.

—The distance between the upper and lower maxillæ when the mouth is naturally closed. *Short or Long Bite.*—The extent of the lap of the upper tooth over the lower. *Shoulder Bite.*—The striking of the occluding teeth upon a shoulder. *Flat-faced Teeth.*—Those intended for cases of

[1] Kindly loaned by S. S. W. Dental Manufacturing Co.

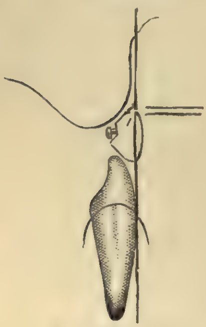
protruding upper jaw. *Bow-faced Teeth.*—Those intended for cases of protruding lower jaw.

The vertical lines represent the facial line.

The two horizontal lines represent the lip line in laughing.

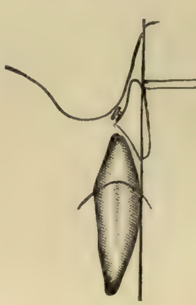
The following cuts illustrate what is meant:

FIG. 422.



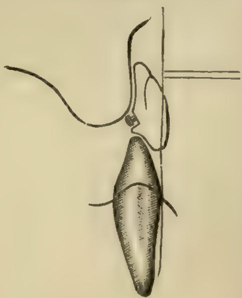
Short ridge lap.
Short shut.
Short bite.

FIG. 423.



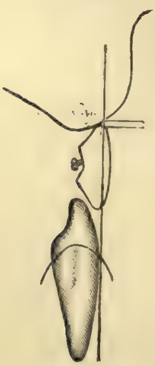
Long ridge lap.
Short shut.
Long bite.

FIG. 424.



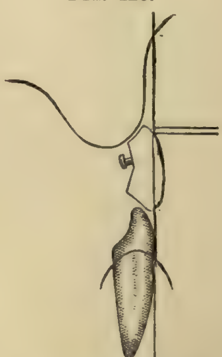
Long ridge lap.
Short shut.
Short bite.

FIG. 425.



Flat-faced tooth for protruding jaw.

FIG. 426.



Bow-faced tooth for protruding lower jaw.

Occlusion and Articulation.

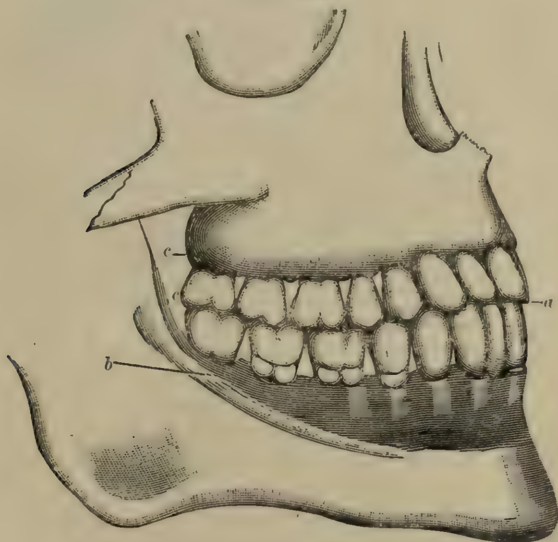
The teeth are arranged in the alveolar process in the shape of a parabola: with the long axis passing between the central incisor teeth, the arch is a little larger in the superior than the inferior jaw (Fig. —).

They are also so arranged that when the mouth is closed naturally they will strike against the opposing teeth in a definite manner, as shown in Fig. 427. When in this position the teeth are said to be in occlusion.

During occlusion all of the superior teeth overlap the lower; the six anterior teeth, superior, pass over and cover part of the labial surface of the six inferior teeth; while in the buccal region the buccal cusps of the superior bicuspids and molars cover to a decreasing extent the buccal cusps of the inferior bicuspids and molars.

This arrangement makes the upper arch a little more prominent and larger than the lower arch. It will also be observed, by referring to Fig. 427, that with but two exceptions each tooth strikes against two opposing teeth, the exceptions being the inferior central incisor, which is

FIG. 427.



covered entirely by the superior central incisor, and the last superior molar, which covers about one-half or one-third of the last inferior molar.

Beginning at the superior central incisor, it will be observed that it covers not only the inferior central, but also about one-third to one-half of the inferior lateral incisor. The superior lateral covers the remaining portion of the inferior lateral and about one-half of the inferior cuspid. The superior cuspid covers the remaining portion of the inferior cuspid and nearly half of the first inferior bicuspid.

It will be seen by this arrangement that the inferior central, lateral, and cuspid occupy a position anterior to the point of the cusp of the superior cuspid—a fact which it is well to remember in the selection of entire sets of teeth, as it fixes the relative size of the six lower to the upper teeth.

By referring to Fig. 427 it will be observed that the first bicuspid, superior, covers the remaining portion of the first inferior bicuspid, and also about one-half of the second inferior bicuspid. This brings the point of the buccal cusp of the first superior bicuspid between the inferior bicuspids. The manner of occlusion of the remainder of the teeth is clearly shown in Fig. 427, and needs no further description here.

When the teeth in occlusion strike as shown in Fig. 427, they are said to represent a normal articulation.

Articulation.—The means for properly masticating the food infers a perfect articulation of the teeth, not only during occlusion of the jaws,

but also during the various movements of the lower jaw in the acts of incising and grinding the food.

The lower jaw is endowed with certain movements by the muscles of mastication whereby the teeth are brought into various relations with each other for the purpose of incising the food when both condyles of the lower jaw move forward and downward in the glenoid fossæ, bringing the cutting edges of the incisor teeth opposite each other for the purpose of separating a small portion of food from the main bulk, prior to the process of mastication.

During mastication, instead of both condyles moving, one condyle only moves forward and downward in the glenoid fossa, protruding the lower jaw to one side or the other. This lateral protrusion, followed by a drawing back into the position of occlusion, is a provision whereby the cusps of the bicuspids and molar teeth, if they are in proper relation to each other, can be utilized for the comminution of the food.

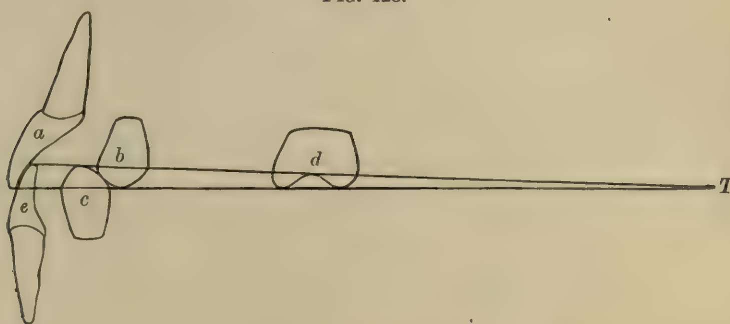
It is a fact that, owing to careless methods in vogue, the movements of the lower jaw for the purpose of mastication, with a large percentage of artificial dentures, are restricted simply to the up-and-down movements of the jaw or the movement of occlusion. By such a movement of the jaw, instead of mastication the patient is limited to only a crushing of the food, swallowing it without the proper insalivation which follows the free and unrestricted use of the lower jaw.

To construct an artificial denture which shall permit of the free and unrestricted use of the lower jaw several points must be carefully considered, and these cannot be better presented than in the language of Dr. Bonwill, who is the author of a series of articles entitled "The Geometrical and Mechanical Laws of the Articulation of the Human Teeth." In these articles he calls attention to a few conditions which exist in every normally articulated natural denture, and with a special apparatus of his own invention, called "the anatomical articulator," he applies his conclusions to the arrangement of artificial teeth. His first important observation is with reference to the shape of the lower jaw, it being of a peculiar tripod arrangement and forming an equilateral triangle. "From the centre of one condyle to the centre of the other four inches is about the average distance, and it will also be found that from the centre of each condyloid process to the median line at a point where the inferior centrals touch at the cutting edge is also about four inches." The sides of these angles, he asserts, never vary more than half an inch, which would make little difference in describing the arc of a circle. "No matter what the width from one condyloid process to the opposite process, the distance is the same from the processes to the median line of the lower jaw at the cutting edges of the central incisor teeth." . . . . "The jaw forms a perfect triangle for the purpose of bringing into contact the largest amount of grinding surfaces of the bicuspids and molars, and at the same time have the incisors on one side at once come into action during those lateral movements." . . . .

"It will also be found that from the cuspids, the bicuspids and molars run in nearly a straight line, instead of a circular one, back toward the condyloid process, enabling them to keep the largest amount of surface always presented for mastication." The next important observation has reference to the position and relation of the incisor

teeth: "The upper incisors should over-jet the lower incisors, while the lower have a corresponding under-bite; without this arrangement the incisor teeth would lose their function. Were the incisors to strike directly upon each other, the power to cut off food would be very much lessened. The normal arrangement of the incisor teeth is shown in Fig. 428. Where there is an over-bite and an under-bite of the incisor

FIG. 428.

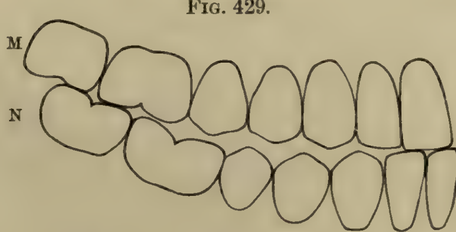


teeth, just in proportion to their depth will be the length of the cusps of the cuspids, bicuspids, and molars."

The next observation has reference to the curvature of the teeth in the jaw, which is formed by the dipping down of the second bicuspid and shortening of the posterior cusp, with a turning upward of the first and second molar teeth toward the condyle of the jaw, as illustrated in Fig. 430, and is also illustrated in Fig. 427, which is reproduced from a life-size engraving from Black's *Dental Anatomy*. This vertical curvature "commences at the first molar tooth, although it shows itself slightly at the bicuspids; practically, it need only commence at the first molar, and this curvature is proportioned to the under-bite and over-bite of the incisor teeth."

The purpose of this curvature at the ramus, as shown in Figs. 427 and 430, is obvious: when the lower jaw is protruded during the incisive function (Fig. 429) the molar teeth are in contact at the same

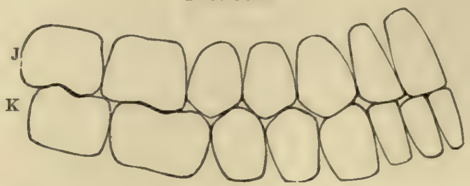
FIG. 429.



time as the cutting edge of the incisor teeth, while the cuspids and bicuspids swing free. This prevents anything more than mere contact of the incisor teeth; and, applying the principle to the arrangement of artificial teeth, it establishes contact at the heel of the plate at the same time the incisor teeth strike, and prevents the displacement of the den-

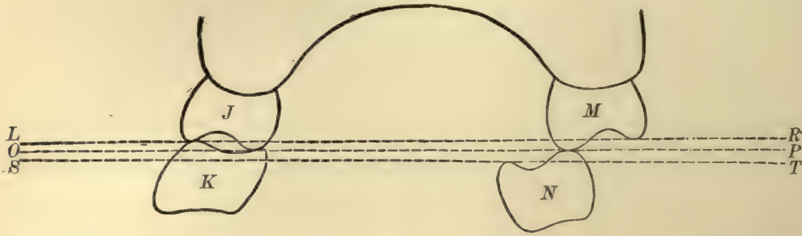
ture. The length of the cusps of the bicuspid and molar teeth has a definite relation to the lateral movement of the lower jaw. The buccal

FIG. 430.



cusps of the lower bicuspid and molar teeth are usually shorter than the lingual cusps, while the reverse is true of the upper bicuspids and molars. The purpose of this arrangement can be easily seen by referring to Fig. 431. When the lower jaw is extended to the left side, as

FIG. 431.



in the figure, and mastication is being performed on the left side of the mouth, the cusps, both the lingual and the buccal, are found opposite each other, while the food is pressed into the sulcus between these cusps. Now, if there is no contact upon the opposite side of the mouth, the plate would be in great danger of tilting or dropping on the side opposite the one in use. But by the proper shaping of the cusps of the bicuspids and molars we find that we can obtain upon the opposite side of the mouth contact between the lingual cusps of the upper molar teeth and buccal cusps of the lower molars, which prevents displacement of the denture opposite the side in action.

"By drawing two lines from *T* to *a* and *T* to *e*, in Fig. 428, we have the lengths of the cusps of the bicuspids, *b* in the upper and *c* in the lower, and also *d*, the second upper molar. The depth of the under-bite is one-eighth of an inch from the cutting edge of the inferior central incisor, *c*, to that of the superior central incisor, *a*. Did the teeth extend as far back as *T*, there would be flat surfaces at those points. But in articulating artificial teeth, when the superior second molar is reached its distal cusp has to be raised from line *Te* to *Ta* (Fig. 428) to allow the molar teeth on the opposite side, not in mastication, to touch for merely balancing the plate, as Fig. 431, *M*, *N*; otherwise the second molars would be of no use in lateral movement, nor would the first molars. This curvature at the ramus (see Figs. 429 and 430) commences at the first molar, although it shows itself slightly in the bicuspids. Practically, it need commence at the first upper molar. This curve, then, will always be proportioned by the under-

bite at *a*, *e*. The length of the cusps or bicuspids will never be more than an eighth of an inch normally; the groove deeper than that would cut the palatal cusp off and make of it a cuspid. It would in reality be cut in twain.

"So that when a first superior bicuspid is seen it can very well be told from the length of the cusps whether the jaw from which it came had a depth of under-bite of one-sixteenth of an inch or more. Where the teeth all strike fairly one upon the other, without over-bite, then there is no occasion for cusps. If originally there, they would soon be worn off from the abnormal articulation."

As the lower jaw is drawn into position, the buccal cusps of the lower molars travelling into the sulcus and toward the lingual cusps of the upper molars on the side in use, we find the buccal cusp of the opposite lower molar travelling toward the buccal cusp of the upper molar on the side not in use, keeping a constant contact for the purpose of supporting the denture upon that side of the mouth during mastication on the opposite side. The same principle holds good when mastication is performed on either side of the mouth.

Fig. 431 shows the position of molars and bicuspids during mastication on the left side, with a balancing contact of the molar teeth on the opposite side of the mouth.

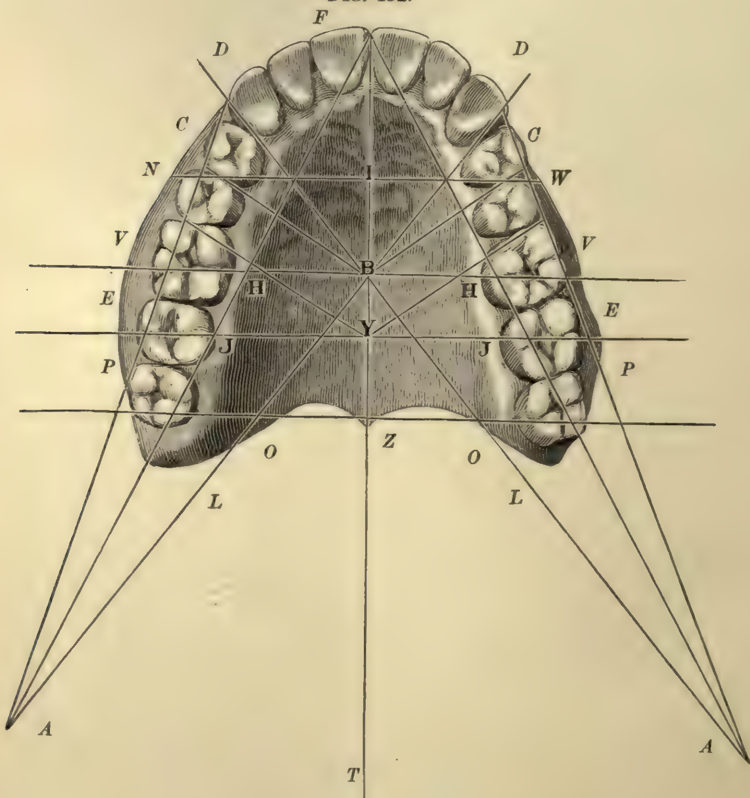
The next observation made by Dr. Bonwill has reference to the relative position and size of the teeth in the arch. This is illustrated in Figs. 432, 433. An equilateral triangle is formed with a base of four inches, the distance from the centre of one condyle of the lower jaw to the centre of the opposite condyle, and represented by the points *A*, *A* in the figures. From the points *A*, *A* a line is taken to the cutting edge of the central incisor teeth at the median line, which represents the apex of the triangle.

We now take a pair of dividers and obtain the combined width of the superior, central, lateral, and cuspid teeth on one side. A line is now drawn from the point (*F*), or the cutting edge of the superior central incisors at the median line, to a point between the condyles, or midway between the points *A*, *A* (Fig. 433). This line extends from *F* to *T* in the diagram, and represents the median line of the mouth throughout its entire extent. The point of the dividers is now placed at the cutting edge of the superior centrals at point *F*, while the other foot of the divider is placed at point *I* on the median line, or just the distance of the width of the superior central, lateral, and cuspid teeth on one side. The point of the divider resting at *I* is held firmly in position, while the point of the divider at *F* is made free, and a complete circle described. The anterior segment of this circle which intersects the median line at *F* gives the exact size of the arch as it falls directly upon the cutting edges of the incisor and cuspid teeth. It marks the extreme limit and prominence of the cuspid tooth. If a line be drawn at right angles to the point where this circle intersects the median line at *Y* (Fig. 432) (or twice the distance of the combined width of the superior central, lateral, and cuspid) from the apex of the triangle, it will fall through the centre of the second molar tooth. After arranging the six anterior teeth according to the measurements given, a straight line is taken from the condyle of one side of the mouth to the distal surface of

the cuspid tooth on the opposite side of the mouth. Another line is drawn from the condyle on one side to the cuspid tooth on the opposite side at its distal surface. These lines intersect the median line at *B*.

Dr. Bonwill asserts that a line drawn at right angles to the median line at the point *B* (Fig. 432) will pass through the centre of the first molar tooth. It may be stated with reference to this line that its position can be slightly altered according as the width of the incisor teeth is greater or less, and also the width of the bicuspid teeth, but the discrepancy is so slight that it makes but very little practical difference in the arrangement of an artificial set of teeth. By reference to Fig. 432, which is taken from a life-size engraving in Black's *Anatomy*, it will be found that the horizontal line passes through the middle of the disto-buccal lobe of the first molar tooth instead of through the centre of the tooth.

FIG. 432.



The arrangement as shown in Black's *Anatomy* has been more universal in the measurements made than that shown in Dr. Bonwill's diagram.

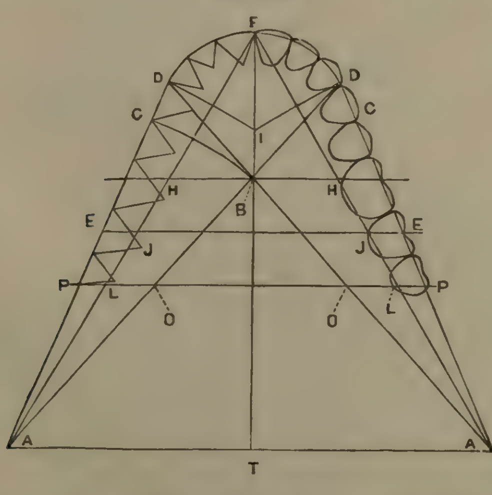
One point of the divider is next placed at *A* (Fig. 432), and the opposite point at *B*, and a curve described toward the buccal surface of the mouth from *B*, and it will be found that this gives a space between the

curve and distal surface of the cuspid tooth, which fixes the width of the first bicuspid tooth. One point of the divider is kept at *A* and the other point retracted to *Y;* a second outward curve is then described, and the space between these curved lines gives the exact width of the second bicuspid tooth. The next line is taken from a point at the distal surface of the cuspid tooth to the condyle of the jaw, which Dr. Bonwill claims will pass through the buccal cusps of the bicuspid and molar teeth—teeth approximating the natural or normal. This line, however, has been found in normal dentures to deviate slightly from the diagram shown by Dr. Bonwill. By reference to Fig. 432 it will be found that the two bicuspids and first molars will fall with their buccal cusps upon this line, while the second molar is turned inward, toward the median line of the mouth, and is missed entirely by the line from *A* and *B* (Fig. 432).

This seems to be a more advisable arrangement of artificial teeth, for if the diagram of Dr. Bonwill is followed exactly, the disto-buccal cusps of the second molars are thrown too far from the ridge, and there is great danger of excessive leverage at this point, which would not be the case if the second molar was turned toward the median line, as shown in Fig. 432.

With the exception of this tooth and the position of the line which defines the centre of the first molar no exception is taken to Dr. Bonwill's measurement. While the drawings represented in Figs. 429, 430, 431, and 433 are theoretical, they are nevertheless true; but in order to make this subject more practical two engravings from life are shown in Figs. 427 and 432, with the measurements as given by Dr. Bonwill (page 372).

Fig. 433.



In following out the measurements as given below the reader can make reference to both Figs. 432 and 433, and can make comparison between the ideal and natural.

[Dr. W. E. Walker of Pass Christian, Miss., in *Cosmos*, January, 1869, calls attention to an anatomical feature of the temporo-maxillary

articulation, together with its consequent effect upon occlusion, which has been overlooked in previous observations. In the Bonwill articulator the instrument is so constructed that the plane of the temporo-maxillary articulation is parallel with that of the occlusion of the teeth. The opening of the jaws of the articulator to bring the tips of the inferior and superior incisors into contact corresponds with the depression of the inferior maxilla. In the Bonwill instrument the angle formed by the joint portion with the horizontal line is but about 10° to 15°. Dr. Walker shows that the angle in the living subject, from which the condyle of the inferior maxilla diverges from the horizontal plane of the glenoid cavity, is, upon an average, 35°. He has studied carefully this forward and *downward* path of the head of the bone, and has constructed an instrument which follows accurately the movements of the human jaw according to its variations in individuals. Models of a perfect denture placed in the Bonwill articulator have not the precise physiological movements observed in the human jaws. Dr. Walker has demonstrated that this discrepancy is due to insufficiency of the angle at which the portion of the instrument representing the head of the bone diverges from a horizontal plane. The models transferred from the Bonwill to the Walker instrument have movements which correspond closely with those observed in the human jaws.—Ed.]

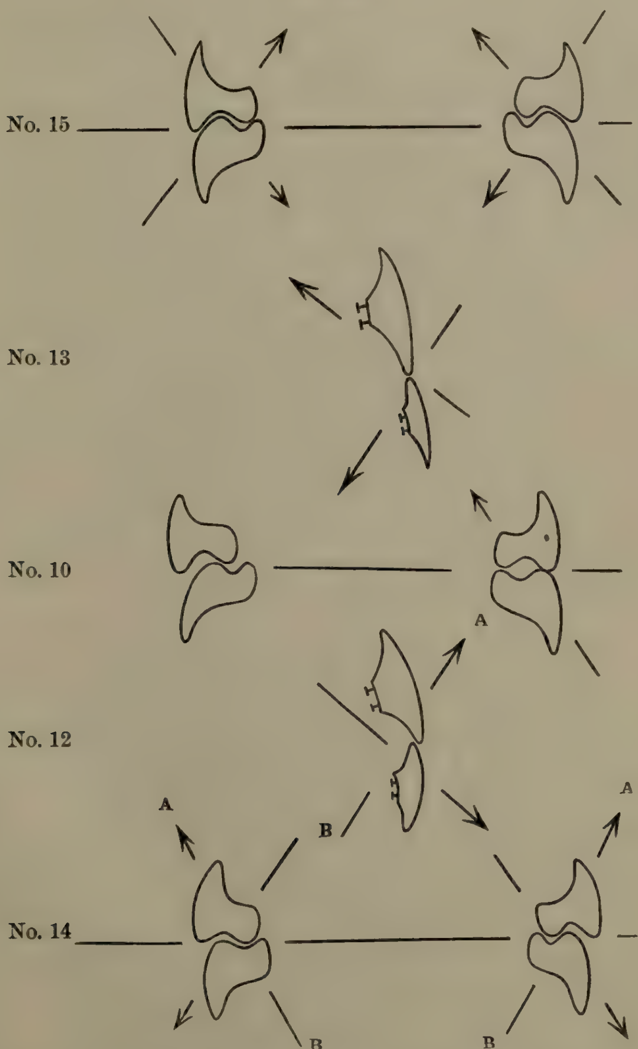
Angles of Force during Mastication.

When the teeth are firmly imbedded in the alveolar process and supported laterally by one another, a slight change in the angle or position of the teeth is of very little importance practically, but the angles at which teeth on an artificial denture are placed contribute largely to the successful or unsuccessful use of that denture. It is absolutely necessary to consider the lines of force, or the mechanical forces, during mastication, in order to prevent displacement of dentures before the cutting edges of the teeth come into actual contact. Fig. 434 outlines the position of the incisors, bicuspids, and molar teeth on opposite sides of the mouth during the incisive function and during mastication, and the lines of force are indicated by the darts.

In a large number of cases where there has been excessive resorption of the ridges it is a rule with a great many operators to project the cutting edges of the incisor teeth toward the lip, while the cervix of the tooth is inclined toward the alveolar ridge. The same is true of the lower incisor teeth, and is indicated by No. 12. If the mouth is thrown open, and there is an attempt to incise with the teeth in this position, the pressure from the lower tooth is against the inner or lingual cutting edge of the upper incisor tooth, and the angle of pressure is shown by the dart from *B* to *A*, which would cause a tilting of the plate at the heel because, there being food between the incisor teeth, there is no contact between the molars. An arrangement of this kind, as shown in No. 12, would have a tendency, as can be seen by the angle of these teeth, to displace by tilting both dentures at the heel. Referring now to No. 13, we find that by inclining the cervix of the superior incisors labially, the cutting edge of the inferior incisors lingually, the line of pressure is toward the centre of the palate above and against the labial cutting edge of the superior incisors, thereby supporting the denture during the pro-

cess of biting through the food. While this arrangement may not be wholly in accordance with a natural denture, and is slightly exaggerated in the figure, the appearance is much better in an artificial set than the same arrangement might be with the natural teeth. The slight change

Fig. 434.



of these angles does not materially affect the appearance of an artificial denture. It must be remembered that No. 13 represents the position of the incisor teeth when the lower jaw is protruded for the purpose of incising. If we refer to No. 14, we observe an arrangement of the bicuspids and molars that usually accompanies No. 12. By the leaning in of the cervix toward the alveolar ridge it can readily be seen that

when there is food between the teeth and pressure is exerted, bringing the lower teeth against the upper, the pressure would be represented by a line from *B* to *A*, and this pressure toward the buccal surface would tend to displace the denture upon the opposite side of the mouth.

It will be observed by reference to No. 15 that the necks of the teeth incline away from the ridge, while their cutting edges lean toward the centre of the mouth. This is the correct arrangement of artificial teeth in occlusion.

The position of the teeth in mastication is shown in No. 10, with the lower jaw protruded to the right side.

If the food be now grasped between the teeth arranged according to this figure, the line of force would be as indicated in No. 10, the pressure being upon the buccal surface toward the centre of the palate, while in the lower it would be toward the median line of the floor of the mouth, as indicated by the darts.

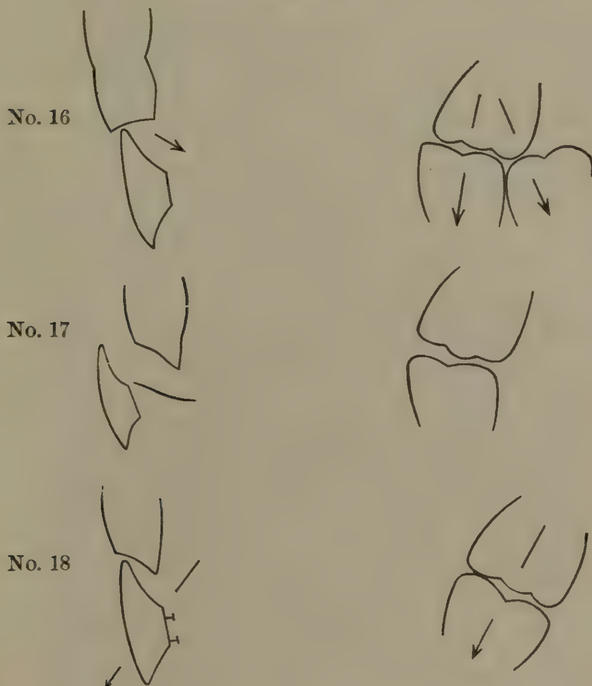
When the jaw is protruded laterally for the purpose of triturating the food, it is gradually retracted, drawn upward and toward the position of occlusion. Until the cutting edges of the teeth strike, the pressure would be toward and against the lingual cusp of the upper molar in the sulcate groove. It will readily be seen that pressure against this point would tend to support the denture on the opposite side of the mouth. If the angles of the teeth are arranged properly, there will be no displacement of the denture while biting through the food until the cutting edges of the teeth strike, unless upon the opposite side of the mouth there was no balancing contact. The real act of mastication occurs after the cutting edges of the bicuspids and molars strike, and if at this time we have contact upon the opposite side of the mouth, we find that the denture would be constantly supported.

By reference again to No. 10 the lines of force indicated are seen until the cutting edges of the teeth strike; now, as the lower jaw is retracted the molars and bicuspids begin to travel, the food being pressed in the sulcate groove between the cusps upward and toward the position of occlusion, the buccal cusps following into the sulcus of the upper tooth, while the lingual cusps of the lower molar travel over the lingual cusps of the upper molar. During this time we find the buccal cusps of the lower molar on the opposite side travelling into the sulcus of the upper molar and toward its buccal cusps, keeping a balancing contact on the side opposite the one in action. A practical application of the angles of force during mastication can probably be more clearly demonstrated by reference to Fig. 435, No. 16. Here is shown a case of lower central incisors and cuspids, with their abraded cutting edges bevelled away from the lingual surface toward the labial side of the tooth. The second molar tooth tilts forward, owing to a loss of the first molar and bicuspid tooth. No. 17 shows a faulty arrangement of the artificial molars in which the same conditions hold good as in No. 16. No. 18 illustrates an arrangement of the molars by which much greater stability of the denture can be secured.

There are other points to be considered in the arrangement of teeth besides mastication. The strength and duration of artificial teeth on a denture or a "bridge," and also the base-plate of the denture as well, depend upon the manner in which the occluding teeth strike. If they strike

as shown in Fig. 434, No. 14, there is a great strain on the superior denture throughout the centre of the palatine portions, which eventually results in a splitting or bending of the plate. The individual teeth are also liable to be fractured or forced from the plate, this latter condition

FIG. 435.



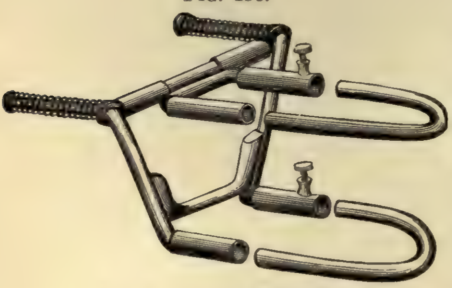
occurring more frequently in ridged appliances, such as bridge-work, and is an extremely difficult break to repair. The direction in which force is exerted during mastication and during the incisive function should be closely observed in order to place the teeth in a position which will enable them to resist that force to the highest degree, or in a position which will afford the greatest mutual support between the base of the denture and the teeth. By giving strict attention to these points many annoying accidents will be avoided.

With the foregoing basis, it remains to adopt some apparatus by which may be studied and obtained the various movements of the lower jaw out of the mouth. As has been seen by the preceding observations, the over-bite of the incisor teeth, the position of the teeth in the arch, the vertical curvature in the bicuspid and molar region, the length of the cusps, all have a definite relation to each other and cannot be followed abstractedly. It will not be possible to carry out the provisions of this articulation without having the means of actual measurement. There is a vertical curvature in the molar region, but this curvature will be of no service unless properly proportioned to the over-bite. If the incisor teeth are arranged with a very slight overlap, "or only enough to prevent

hissing," the incisive function of the incisor teeth is sacrificed, and the appearance of the incisor teeth will be unnatural. If the incisor teeth are arranged regardless of the position of the molars and the natural amount of overlap given, then lateral movements of the jaw will be interfered with, and the patient will be restricted simply to the up-and-down movements of the jaw. Means must be adopted whereby these various conditions can be measured or relatively proportioned out of the mouth, and this cannot be accomplished without being able to obtain the movements of the lower jaw. An instrument for this purpose is the "anatomical articulator."

Anatomical Articulator.—The anatomical articulator is composed of brass wire and tubing, and is illustrated in Fig. 436. It consists of a base and two brass bows, the bows being detachable by loosening the set-screws. The articulator as seen in the cut is in the position for use, the uppermost bow being much narrower than the lower bow. The cross-bar or tube, to which the narrow bow of the articulator is attached, corresponds to the base of the triangle or the line from a to a, Figs. 432 and 433. At either extremity of the cross-bar is an eyelet through which the "condyle" of the articulator works.

Fig. 436.



W. G. A. Bonwill's articulator.

The two spiral springs back of the condyle represent the muscles, and serve to keep the casts in the position of occlusion, except when moved about to get the different bearings of the artificial teeth.

In mounting cases the narrow bow should always receive the upper model, whether that be an articulating model or the model upon which a denture is to be constructed, and the wide bow should at all times receive the model of the lower jaw.

The first step in the process of mounting a case is to loosen the two set-screws and push the brass bows firmly back in their respective sockets, and then hold them by tightening the screws.

Second. Trim the base of the models so that the plane of the base A, Fig. 437, will correspond to the plane of the occluding surface of the wax-bite, B. The plane of the base of the models A, A should be perfectly horizontal, and the wax-bite at B should be also horizontal in the region of the six anterior teeth, as shown in Fig. 437. Attention to these points enables one to mount the cases squarely in the articulator.

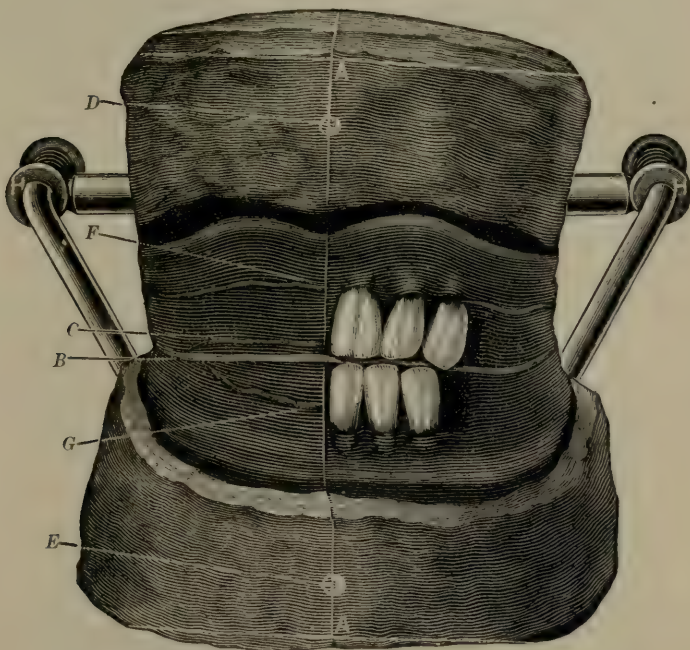
Third. Place the plaster models in position in the wax-bite plates, and fasten them at two or three points by melted wax, to prevent slipping of the models during the mounting process.

Fourth. Place the articulator with the wide bow resting upon a piece of paper on the plaster bench, and the upper bow turned backward.

Fifth. The lower model is now adjusted upon the wide bow, the heels pointing toward the condyles H, H, Fig. 437, with the bite-wax and upper cast also in position when the narrow bow is turned to rest on the upper cast.

Sixth. Take a pair of dividers, opened to measure four inches, and place one foot in a depression at the condyle, *H*, then bring the other foot to the point where the perpendicular (median line) intersects the

FIG. 437.



B, occluding surface of wax-bite; *F*, high lip line; *G*, low lip line.

occluding line, *B*. The distance is now to be measured from the opposite side in the same manner.

Rule.—Let the median line of the mouth, *F* to *T*, Figs. 431 and 432, fall midway between the condyles of the articulator, and at the same time let the median line of the bite at the occluding edge of wax be equidistant (four inches) from each condyle. When in this position pour plaster, quite thin, over the narrow bow and upper model, and at once lift the articular up by the base, and make a bed of plaster on the table into which the wide bow and lower cast are placed. When the plaster hardens the excess should be trimmed away.

In mounting a cast for an upper denture alone there would be only an upper wax articulating plate, and instead of the lower on the occluding surface of the upper bite an impression of the cutting edges of the lower teeth. Take an impression now of the lower teeth in wax and make a model, and when this is separated from the impression place the cutting edges of the plaster teeth in the impression on the occluding surface of the upper bite-plate, and then mount in the same manner as with entire dentures. The above method is also followed in mounting a full lower denture where there are upper teeth, and will also

serve in mounting casts for partial dentures where it is necessary to use an articulator.

Fig. 397 show bites for entire dentures after mounting on the anatomical articulator.

After the plaster which has been used to fasten the models to the articulator has hardened (the plaster above and below the horizontal lines *A*, *A*, Fig. 437, in which the bows of the articulators are fastened), the wax-bite at the occluding surface should be separated to allow the lower model to swing free: the teeth may then be selected.

At this point must be measured the distance from *D* to *B* on the upper cast, and from *E* to *B* on the lower, with the dividers. This distance, whatever it is—say one inch and a half—should be marked on the top of the model by two holes one inch and a half apart.

The divider is now adjusted to measure the distance from *D* to *F*, which is marked on the top of the upper model.

The distance from *E* to *G* is now measured and marked on the lower model.

The longer distance will be recognized as the length of the upper and lower teeth, or lip line, while the shorter distances will represent the high and low lip lines.

The depression at *D* and *E* on the median line of the models is usually selected about the centre of the base of the models.

If the bites become destroyed, these markings may be referred to, and the bite may be re-established with a certain degree of accuracy.

Plain Teeth.

Fig. 407 shows a set of twenty-eight plain teeth. The wax articulating plates, or bite-wax, should represent the exact length of the lips (lip line), *B;* the highest point of elevation of the upper lip, as occurs in laughing, high lip line, *F;* the point of forcible depression of the lower lip, low lip line, *C;* the proper contour of the face and the median line, Fig. 437.

If these points have been faithfully observed, the lower wax articulating plate at the median line represents precisely the position of the inferior central incisor teeth. All that is necessary is to cut down to the base-plate through the median line of the wax, and take out a section, upper and lower, on one side only, to admit of placing the central lateral and cuspid on that side, as shown in Fig. 437. After these teeth are approximately arranged the measurement as given under the heading "Articulator" is to be followed to fix their exact position when they should be waxed fast.

Unless some of the occluding surface of the wax is removed, it would require the teeth to be placed longer than the wax-bite. When the amount of overlap is determined, just that much of the occluding surface of the upper wax bite-plate should be removed, as shown in Fig. 437, *B* to *C*.

After arranging the central, lateral, and cuspid, enough wax is removed to admit the first lower bicuspid, which is placed in the wax a little lower than the lower cuspid. At the distal surface of the cuspid the circle is broken, as only the six anterior teeth form the segment of

a circle. Next turn the bicuspid so that the groove between its diminutive lingual cusp and buccal cusp points straight toward the inner border of the ramus of the jaw.

The next tooth is the upper first bicuspid, which is arranged to occlude with its buccal cusp, overlapping the lower bicuspid.

Next in order is the second inferior bicuspid, which is set a little lower in the way that the first bicuspid inferior was, with its sulcate groove pointing straight toward the inner border of the ramus. It is followed by the second superior bicuspid.

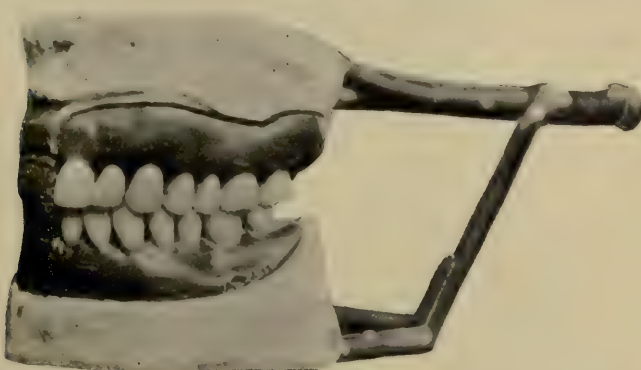
It will now be noticed that the occlusal surfaces from the cuspid to the distal surface of the second bicuspid have been gradually lowered.

From this point, the distal surface of the second inferior bicuspid, the occluding surfaces begin to turn upward. The first lower molar is arranged with its anterior cusps on a level with the second bicuspid, but its distal cusps should be raised slightly above that plane. (See *A*, page 123.)

The second molar inferior is inclined still higher, and when the upper molars are placed in occlusion the vertical curvature is formed, and we must now determine whether it is too great or small for the over-bite.

Fig. 438 shows the teeth of one side arranged in occlusion, and while the upper model and wax-plate are held in position the lower cast and

Fig. 438.



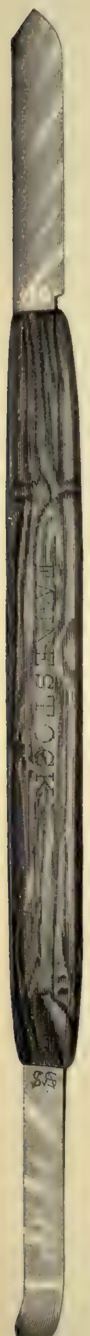
Showing the arrangement of plain teeth in occlusion, and the manner of waxing the buccal and labial surfaces of wax-plates.

wax are brought forward until the cutting edges of the incisor teeth are opposite each other (Fig. 440).

If there is an even contact between the upper and lower last molars and the superior and inferior central incisors, the curvature is correct (Fig. 440).

After this point has been ascertained, the springs of the articulator are to bring the models into the position of occlusion again, when the teeth should be fastened to the base-plate by flowing the melted wax around the pins on the lingual side and over the necks on the labial and buccal sides with a hot wax-spatula, illustrated in Fig. 439. The wax should now be chilled in cold water to prevent loosening of the teeth,

Fig. 439.



Wax-spatula.

when the opposite side should also be arranged after the manner just described.

When both sides are arranged the lower model should be

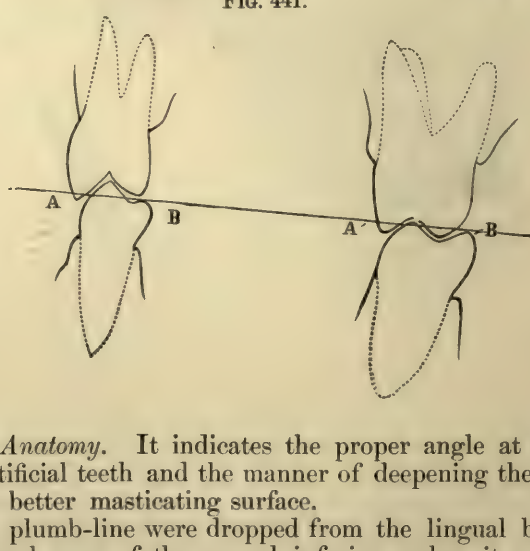
Fig. 440.

Showing the artificial teeth arranged for one side, and the lower jaw protruded for incising: also contact of molars; also of incision while intervening teeth swing free.

protruded, first forward, and then to the right and to the left to see that the teeth are all in proper relation to each other.

The articulation of the cusps of molar teeth is admirably shown in Fig. 441, which is taken from a life engraving from

Fig. 441.



Black's *Anatomy*. It indicates the proper angle at which to place artificial teeth and the manner of deepening the cusps to effect a better masticating surface.

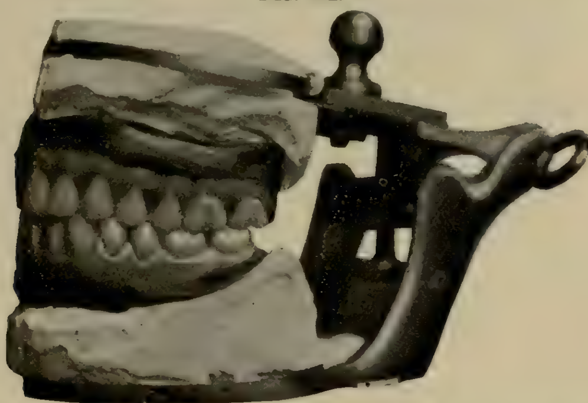
If a plumb-line were dropped from the lingual border of the lingual cusp of the second inferior molar, it would fall clear of the body of the jaw, and not through the centre of the edentulous ridge, as many artificial teeth are arranged. When the teeth are placed too near the cheek it is con-

stantly irritated, and the teeth are, during lateral movement, thrown out of line of use. The position of the molar teeth would be more nearly correct if a perpendicular line falling through the buccal cusps would also fall through the centre of the edentulous ridge. This arrangement might, upon first observation, appear to impede the movement of the tongue. Such is not the case, but, on the contrary, the molar teeth are in the best position to receive the greatest assistance from the tongue and cheek in keeping the food in position for mastication.

The No. 2 Articulator and Gum Sections.

Fig. 442 represents the use of the plain line articulator, or the same as illustrated in Fig. 395. While it is not possible to move the casts

Fig. 442.



Showing the No. 2 S. S. W. articulator, and an upper and lower set of gum sections.

about in this instrument as with the anatomical articulator to get the various bearings of the teeth, the same general rules are followed in the formation of the arch and the arrangement of teeth for entire dentures.

For partial cases this instrument is quite as successful as any other, because the position of the artificial teeth will be governed to a great extent by the natural teeth remaining; but for full dentures some additional suggestions are necessary.

After the bite is mounted, the arrangement of the teeth should be proceeded with after the manner illustrated in Figs. 438 and 439, but the adjustment of the overlap of the anterior teeth should be slight, the superior incisors barely covering the tips of the inferior incisors. There should also be a slight space between the labial surface of the inferior and the lingual surface of the superior incisors, so that these teeth shall not quite touch in the articulator.

The strongest occlusion should be between the superior and inferior bicuspid and first molar teeth, while the inferior second molar should not be in positive contact; and if there are inferior third molars, with the occluding surface pointing forward, these should not be allowed to quite touch the superior artificial teeth.

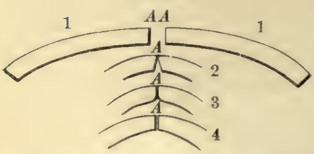
The reason for this is, that after the dentures are placed in the mouth

there is a slight settling, and if the incisors were allowed to strike in the articulator, a more positive contact would follow in the mouth, which would cause a tilting of the plates. Again, if the last molar strikes too forcibly, the denture would be crowded forward, and not only loosened, but the mucous membrane would be considerably irritated by the friction.

Fig. 442 illustrates the use of "gum section" teeth, the first section containing a central and lateral incisor and the cuspid tooth; the next section, the two bicuspids; and the next, the two molars. It will be seen that the use of section teeth requires a different method of arrangement, two or more teeth being placed at the same time. On the proximal margin of each block or section there is an excess of porcelain gum, which is to be ground off to the required amount to permit of articulating the cutting edges.

This is called the *jointing process*, and must be performed very carefully in order to obtain a properly finished piece. If the joints are not properly made and protected, the dark vulcanite will be forced through in vulcanizing and produce a discolored joint.

Fig. 443.



1, 1, horizontal section of the porcelain gum of a block of three; *AA*, proximal edges to be joined; 2 *A*, V-shaped or imperfect joint; 3 *A*, proper method of jointing sections for vulcanite; 4 *A*. proper method of jointing for plate or solder work.

Fig. 443 illustrates in No. 1 a horizontal section through the gum enamel of a porcelain block and the approximating edges *A A*, the surface to be joined. If care is not taken, the result after grinding may be as shown in No. 2, the labial surface in contact with a V-shaped space back of it, and during the contraction of the vulcanite in the hardening process the two blocks may be drawn so forcibly against each other as to fracture a piece of the porcelain enamel.

No. 3 indicates the proper method of forming the joint for vulcanite work. From one-half to two-thirds of the thickness of the blocks toward the labial surface should be joined squarely against each other, while the inner third should be given a slight bevel, as seen in No. 3.

Fig. 444.

Showing an upper set of single-gum plate teeth on gold plate, illustrating the manner of jointing.

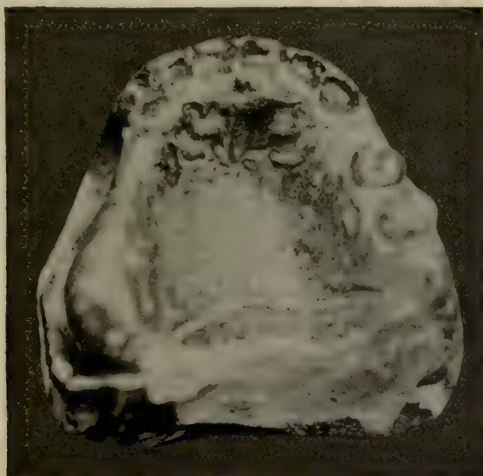
After the case is inverted this V-space is to be filled with cement to prevent the vulcanite from being forced through the joint.

Single gum teeth for gold plate work should be joined squarely against each other through the entire thickness of the block, as shown in No. 4, while the complete set, so ground, is shown in Fig. 444.

Temporary Dentures.

A distinction is made by many operators between "permanent" and "temporary dentures." Strictly speaking, any artificial denture might

Fig. 445.



A cast showing recent extraction of six anterior teeth.

Fig. 446.

Showing the arrangement of teeth necessary in a case like Fig. 445, where the six anterior teeth were recently extracted.

be considered as temporary, and none as permanent. But as these terms have been given a special significance, regardless of their real meaning.

"Temporary denture" is a term applied to a denture inserted immediately upon or soon after the extraction of the natural teeth, or before the process of resorption is complete.

Fig. 445 illustrates a mouth from which the bicuspids and molars of one side had been extracted some six or eight months before the anterior teeth. Resorption has been completed in this region, and the sockets from which the teeth were extracted perfectly obliterated.

The anterior portion of Fig. 445 shows the margins of the sockets from which the six anterior teeth have been recently extracted, the impression being taken as soon as bleeding had ceased. In such a case no artificial gum will be required, as the ridge is already sufficiently prominent. The crowns of the artificial teeth should be placed in the position formerly occupied by the natural teeth, with the neck of the tooth extending slightly into the empty socket. The outer wall of the socket is formed by the labial alveolar plate, and the labial surface of the neck of the artificial tooth should fit snugly against this in order to have the natural gum form nicely around it.

Fig. 446 shows the arrangement on a plain line articulator, with the artificial crowns projecting from the natural gum, and the appearance for a time is natural and agreeable. Back of the cuspid teeth, where resorption is complete, we see the bicuspid and molar teeth arranged with an artificial gum, which is brought forward to the distal surface of the cuspid tooth. This figure (446) also illustrates the arrangement of a partial lower case in connection with an upper having two molars on either side.

The Arrangement of Teeth in Abnormal Protrusion of the Lower Jaw.

In the preceding illustrations and text the attention of the student has been directed to normal conditions, and the normal arrangement of artificial teeth with those conditions, in order that he may familiarize himself with the various methods and principles involved, and be able to modify them in the treatment of abnormal cases.

Fig. 446 may be considered a fairly normal relation of the edentulous ridges, and one with which all of the rules governing a normal articulation can be followed out with a certain degree of accuracy.

Fig. 447 shows an extremely abnormal relation of the alveolar ridges, and one requiring a considerable modification of the usual methods in order to arrange the teeth in a manner at all satisfactory. A protrusion of the lower jaw, however, within certain limits may be met with occasionally, and a normal arrangement of the teeth obtained, providing that other conditions are favorable to it. But, before attempting to arrange the teeth in such cases, and while the patient is still at hand, the operator must make some careful observations.

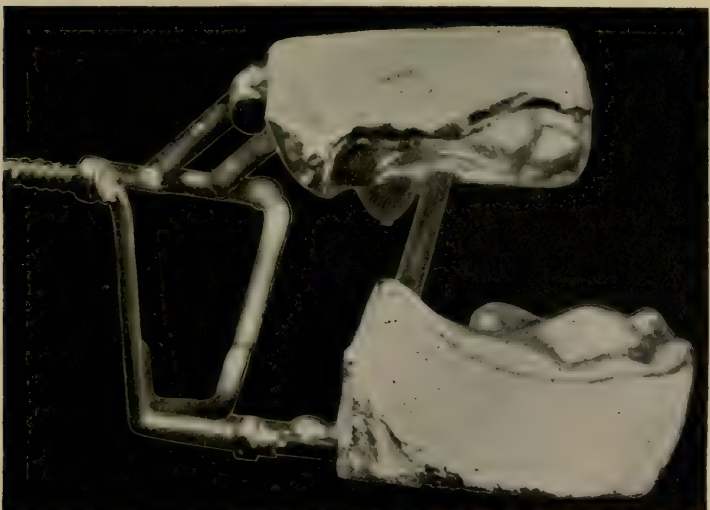
First, to ascertain whether the lower teeth can be retracted sufficiently to obtain an over-bite without interfering with the movements of the tongue.

It is seldom possible to adjust the lower teeth toward the tongue farther than the centre of the edentulous ridge. If such an operation is attempted, the movements of the tongue will not only be impeded and

speech impaired, but the stability of the denture will be affected by the tongue constantly pushing against it.

Second.—It must be ascertained whether the tissues of the upper lip

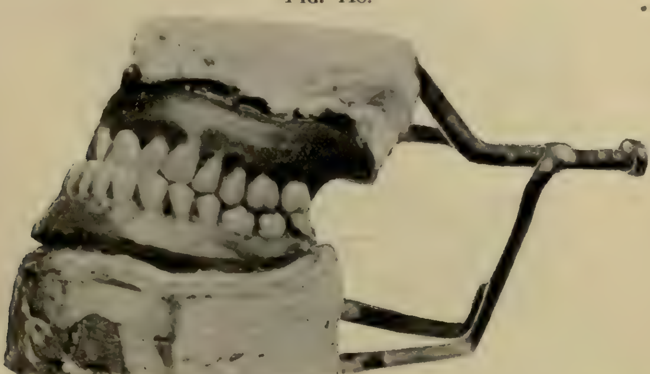
FIG. 447.



Showing extreme protrusion of the lower jaw, and with antagonizing casts on the anatomical articulator.

are sufficiently lax to permit of bringing the upper teeth the necessary distance forward from the alveolar ridge to obtain an over-bite.

FIG. 448.



Showing the arrangement of teeth necessary in a bite when the lower teeth close outside of the upper.

Third.—Will the removal of the superior incisor teeth from the alveolar ridge cause a continual loosening of the denture by excessive leverage on these teeth?

Fourth.—Whether the attempt to obtain a perfect profile will effect too radical a change in the patient's appearance.

Fig. 448 illustrates the arrangement of teeth necessary in case of protrusion so extensive as in Fig. 447. The upper incisor teeth are arranged to close inside of the lower, with their labial surfaces gliding closely on the lingual surfaces of the inferior incisors, the incisive function being performed in a reverse manner to that of a normal arrangement.

When the superior cuspid tooth is reached the first attempt is made to merge into a normal arrangement.

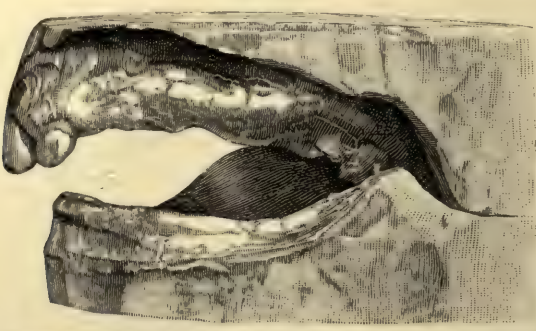
This tooth is placed with its anterior cutting edge covered by the inferior cuspid, while the distal cutting edge is turned labially and ground so as to strike directly on top of the mesial cutting edge of the first inferior bicuspid. The first bicuspid, superior, is ground and brought out slightly more than the cuspid, and from this point distally the teeth assume their normal position. In order to obtain a graceful arrangement in such a case, as seen in Fig. 448, it will be necessary to do considerable grinding and lapping of the upper teeth, which is not at all unsightly in this character of case.

The facial expression following such an arrangement of the teeth will be improved. In marked protrusion of the lower jaw, where the natural teeth close outside of the upper, and when this condition has existed up to middle life with natural teeth, a correction of the facial expression with artificial teeth should not be attempted.

The Arrangement of Teeth in Abnormal Protrusion of the Upper Jaw.

A case directly the opposite to the one illustrated in Fig. 447 is shown in Fig. 449. In this case the protrusion of the upper ridge was about half an inch beyond the lower, and, while there was an over-bite

Fig. 449.



Showing plaster articulation of a case with extreme protrusion of the upper jaw.

of the upper teeth, the position of the ridges would not permit of bringing the lower into contact with the upper for the natural performance of the incisive function. This function was established between the cutting edges of the lower incisor teeth and the base-plate of the upper denture. The six anterior teeth were permitted to barely strike the base of the upper denture when the opposing bicuspids and molars were in occlusion.

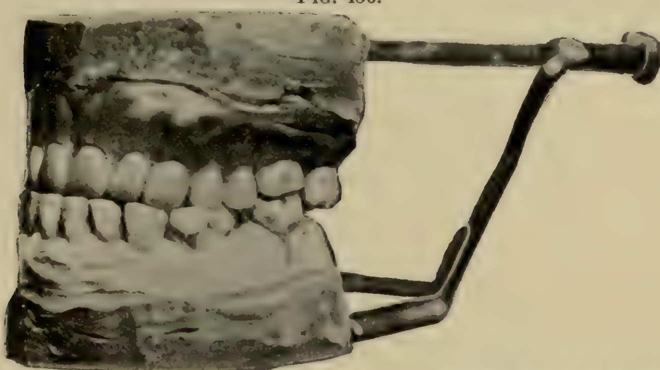
Another feature of this case was the arrangement of third artificial molars, which with the one natural molar gave a masticating surface of

four molars on either side above. The cut shows the exact size of the casts and their relation to each other, indicating the necessities of the case better than if the artificial teeth were shown.

Direct Antagonism of Opposing Teeth.

A third form of abnormality is shown in Fig. 450. While this case is termed abnormal in comparison to an ideal arrangement, it is not abnormal, strictly speaking. The abrasion of the cutting edges of the natural teeth from many years of hard use and other causes, together

Fig. 450.



Showing the arrangement of upper teeth directly upon the abraded ends of the lower natural teeth.

with a destruction of the natural over-bite caused by the obtusing of the angle of the lower jaw, which occurs with advancing age, is a natural consequence, and direct antagonism of the opposing teeth is perfectly normal under such conditions.

Persons of an advanced age, who have lost all of the upper teeth, but who have retained a number of the lower teeth, as shown in the illustration, are frequently seen. These teeth are so abraded that no signs of cusps remain, and perfectly flat surfaces are presented upon which to articulate the artificial teeth. If an attempt is made to articulate teeth with cusps to these flat surfaces, only the points of the cusps will be in antagonism, which would deprive the patient of a thoroughly useful appliance. An over-bite would also be unnatural, for whenever we find the bicuspids and molars abraded there is usually a corresponding abrasion of the incisor teeth, and if the patient had retained the upper teeth, they would have been affected in the same manner, and antagonism would have been directly upon the cutting edges.

In articulating an upper denture to lower natural teeth with the above conditions existing, one feature must be prominently borne in mind by the operator—viz. to offer no obstacle to the perfect freedom of the lower jaw. To this end the artificial teeth should be articulated directly upon the ends of the lower teeth: the cusps of the upper teeth should also be ground off and the flat occlusal surface roughened. This arrangement will permit a free lateral movement of the lower jaw, and mastication will be performed after the manner of the millstones in

crushing grain. While this arrangement may not afford the best means of performing the incisive and masticatory functions, it is the best that can be done under the circumstances.

When arranging teeth to strike directly upon their cutting edges, the lines of force must be carefully studied, and any point likely to produce leverage upon the denture must be shaped so as to offer its portion of support. The upper incisor teeth should not be allowed to strike the labial cutting edges of an abraded lower, but should be placed squarely in the centre of that tooth. The cutting edge of the lower teeth can with advantage be grooved slightly, mesio-distally, and the upper teeth articulated to this groove, as shown in Fig. 435, No. 18.

Fig. 450 will also illustrate Fig. 435 as regards the position of the incisors and molars. In the arrangement of the bicuspid and molar teeth in such cases care must be taken not to allow the antagonizing buccal edges of the opposing teeth to strike on the same line. The upper teeth should be projected either buccally or lingually, so that one or the other of the teeth will drive the cheek and tongue away from the line of occlusion; otherwise there would be great danger of injury to these tissues every time the mouth is closed.

Partial Dentures.

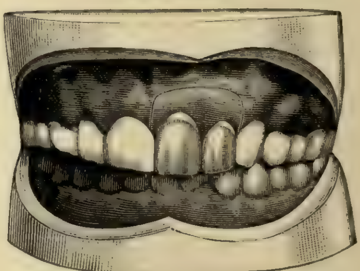
In the selection and adjustment of the teeth in partial cases the operator is governed largely by the degree of resorption of the alveolar processes at the edentulous spaces.

In Figs. 451 and 453 we observe the loss of the left central and lateral incisor, and, while either case requires an artificial central and

Fig. 451.

A cast indicating the need of a gum section.

Fig. 452.



A cast showing the ajustment of a gum section containing a left central and incisor.

lateral incisor that will harmonize with the natural teeth of the opposite side, the two cases require an entirely different method of treatment.

Fig. 451 exhibits considerable resorption of the ridge between the points *A A*, and should plain teeth be used here it would require a considerable thickness of vulcanite or celluloid gum to properly restore the contour of the ridge. A vulcanite or celluloid gum is contraindicated in such a case—first, on account of its unnatural appearance; second, because it is not sufficiently strong and is liable to fracture in a short time.

The proper method of treating these cases is with a sectional *block of gum teeth*, as illustrated in Fig. 452. A block with the porcelain gum as near the natural color as possible is selected, with teeth of the proper size, color, and form. Before attempting to adjust the block the plaster model should be scraped slightly, as shown at the points *A A*, in order to obtain a close joint between the artificial gum and the natural. The block should now be carefully placed in the space, so as not to mar the contiguous plaster teeth. The points of contact should be ground off slightly from the block until the surface of the artificial gum is continuous with that of the natural, and the artificial teeth on a line with those of the plaster cast. It should now be fastened to the model by melted wax, and the lingual side of the plate prepared for investing.

Fig. 453.

A cast indicating the need of plain teeth.

Fig. 453 shows a model similar to 452, where but little resorption has occurred. Plain teeth are here indicated, and should be so adjusted that when the piece is finished their necks will be slightly imbedded in the gum-tissue of the ridge. To accomplish this the ridge on the model should be scraped at the points where the necks of the teeth impinge, as shown in Fig. 453. The teeth should be ground so that they may be placed in alignment with the natural teeth represented on the plaster cast. (See Fig. 454.) They should then be fastened with wax, and the lingual side of the base-plate prepared for investing.

Aside from the above conditions, which suggest the use of gum or plain teeth, we must consider the *bite* in order to determine whether we can use teeth with headed pins or those with headless pins (*plate teeth*). In the two illustrations there is sufficient space between the cutting edges of the lower teeth and the edentulous ridge, consequently we can easily use teeth with headed pins if the case is to be of vulcanite or celluloid. If it is to be a gold plate or silver, then plate teeth should be

Fig. 455.

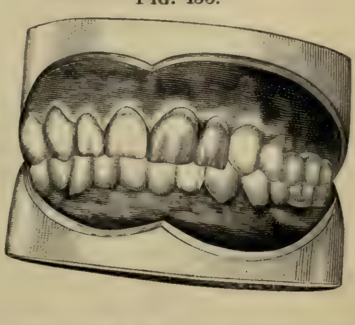
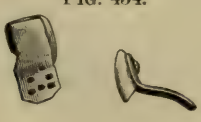


Fig. 454.

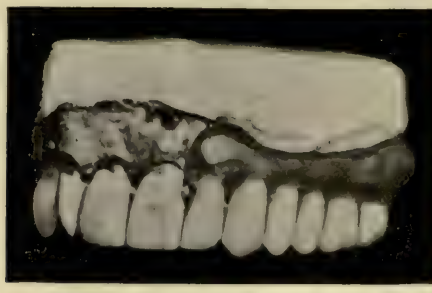


used. If, however, the lower teeth almost touch the edentulous ridge, the use of teeth with headed pins would be contraindicated, because they would require too much thickness to the plate and would prevent the natural teeth from occluding. When the bite is *close* and a vulcanite plate is contemplated, *plate teeth* should be selected and lined or backed with gold, as shown in Fig. 454. The thin gold tag attached to the backing may extend posteriorly far enough to receive a firm attachment in the

vulcanite plate (see chapter on Vulcanite), while the thin gold will permit the natural teeth to occlude. The anterior view would not be unlike Fig. 452 or Fig. 455.

Fig. 456 illustrates an extensive partial denture and the use of teeth

FIG. 456.



Showing the use of teeth with extended necks, commonly known as "celluloid teeth." The two centrals and right lateral incisors are natural, and have suffered recession of the gums; the artificial teeth are selected to correspond.

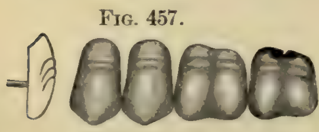
with extended necks, commonly known as teeth for celluloid work. It will be seen by the figure that the two centrals and right lateral incisor are natural teeth which have suffered recession of the gums, causing part of the root to be exposed. While the lip of the patient would roll high enough in laughing to expose the neck of the teeth, it did not rise sufficiently high to expose the unnatural gum of the denture.

Failures with Partial Dentures.—Failures with partial dentures are largely due to carelessness in adjusting the artificial teeth, to avoid which the student is directed to the following observations:

Whenever a block or plain tooth is to be placed in contact with the mucous membrane of the ridge, it is necessary to scrape the points of contact on the plaster cast slightly, in order to obtain a clean joint between the natural and artificial gum. In vulcanite work the scraping should be a little more extensive than in soldered, for during vulcanization the rubber forces the block or tooth away from the ridge a little, which would cause a dark line between the tooth and natural gum, or there would be a space. Scraping is done to compensate for this slight moving of the block or tooth, also to obtain a little pressure upon the natural gum to ensure a clean joint. The degree to which this is to be performed depends upon the compressibility of the gum-tissue in the mouth, which should be examined carefully before an alteration of the model is made.

Wherever there are natural teeth which occlude in the mouth requiring a partial denture, these should never be held apart by the appliance, except for extreme reasons. It not infrequently happens that an appliance consisting of the bicuspids and first molar for both sides is necessary. The bite is very close, not giving enough room for cusps upon the artificial teeth without holding the natural teeth apart. In such a case facings or veneers are used, which have the appearance of the bicuspid and molar teeth, but

FIG. 457.



are perfectly flat on the reverse side. (See Fig. 457.) These teeth are made for either vulcanite or solder work, but are most exclusively used for bridge-work. By using veneers or facings the outward appearance of the denture can be made satisfactory, while cusps, if necessary, can be built up with the vulcanite or gold to any required height.

As a rule, the artificial tooth should be of the same general form and shape as the natural tooth for which it is a substitute, but this rule cannot always be followed. It is generally better to place a cuspid tooth back of a natural cuspid, even though there be room for the lingual cusp of a bicuspid. The sudden thickening of the denture at this point when beginning with a bicuspid tooth is a serious impediment to the tongue, which would not be so noticeable if the appliance were started with a cuspid—though narrower than the natural cuspid or a veneer—then following this with a well-formed second bicuspid.

A single artificial incisor or a central and lateral, as shown in Figs. 452 and 455, should be placed with their cutting edges a little longer than the adjoining tooth on the plaster cast, to allow for the settling of the denture. If they are placed the exact length at first, after a few days' wearing they will appear shorter than the natural teeth.

Artificial teeth should be selected to correspond exactly with adjoining natural teeth in color, shape, and size.

The Proper Conformation of the Lingual Surfaces of Dental Plates.

Trouble is often experienced by patients in securing a clear and sharp *s* sound after they have commenced the use of artificial dentures. A peculiar whistling sound is produced.

It is now proposed to give a short description of the mechanism by which these sounds are produced, and to draw attention to the importance of giving due consideration to the shape of the lingual side of the plate if it is desired to secure clearness and ease of articulation of the sound above referred to.

Inspection of models of the upper jaw in which the natural teeth are in place will show that while the lingual surface of the bicuspids and molars practically forms a continuation of the lateral curve of the palatal arch, the alveolus behind the incisors is thickened. With the rugæ a nearly flat triangular space is often produced, bounded by a line connecting the distal surfaces of the laterals and the edges of the alveolar sockets. Viewed in longitudinal section, a reversed curve is presented, extending forward from the hard palate and merging into the hollow outline of the lingual surfaces of the incisors.

Sections of models from different mouths are shown in Figs. 458 to 463. The curves will be seen to present nearly the same general shape, whether the arch be deep, like Fig. 459, or shallow, like Fig. 461.

In Figs. 462 and 463 an attempt has been made to show the relative positions of the tongue and teeth in making the *s* and *sh* sounds. In producing the *sh* sound (Fig. 463), the upper and lower teeth are held slightly apart; the tip of the tongue rests against the gum behind the lower incisors, its edges impinging upon the lingual surfaces of the bicuspids and molars at the junction with the alveolus. The result is a narrow passage over the centre of the tongue, the narrowest portion

being just back of its tip, the passage being thus gradually enlarged both behind and before its narrowest portion. The breath, being forced through this narrow passage, follows its curve, and is impelled against the tips of the lower incisors, the result being the *sh* sound.

FIG. 458.

FIG. 459.

FIG. 460.

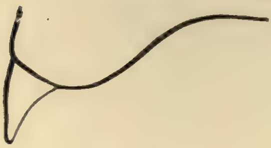
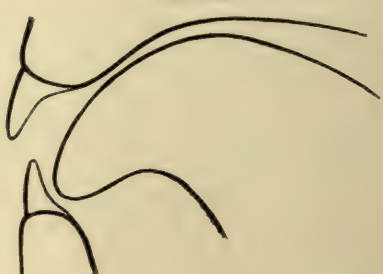


FIG. 461.

FIG. 462.

FIG. 463.



In giving the *s* sound (Fig. 462) all the parts remain in the positions above described, except the tip of the tongue, which is curved upward to the alveolar border on the lingual side of the upper incisors, making the passage smallest at its outlet and projecting the current of air against the upper incisors. It will be found by experiment that if the tongue is drawn backward a little from the position described, the hissing-sound

FIG. 464.

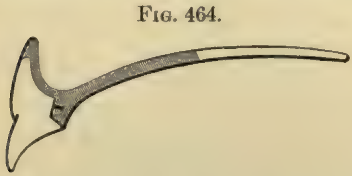
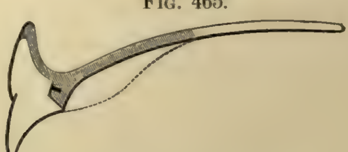


FIG. 465.



will be changed to a whistle. It will be noticed that the shape of the palatine arch is such that the tongue can readily conform to it, and that a passage between the tongue, palate, and alveolar border can be readily formed by which a clear articulation of the sounds in question can be produced.

As a contrast to the figures already shown, attention is directed to Fig. 464, which is a section of a fairly well-made vulcanite plate. The teeth are well arranged, the joints close and well fitted, the finish good. It will be observed that the palatal curve, if continued, would meet and coincide with the curve of the lingual surfaces of the incisors, there being a break at the point of junction of the teeth and rubber; and this is so abrupt that it would be impossible for the tongue to follow its outline, as it does the curve of the natural arch in Figs. 463 and 464. The reversed curve, shown in Figs. 458 to 461, is plainly out of the question. The sketch illustrates what is by no means an extreme case. With thinner teeth and a longer bite the defect noted would be still greater.

If the plate which is shown in section in Fig. 464 were filled in to present the outline shown in a dotted line in Fig. 465, the enunciation of the wearer would be improved, and another very substantial benefit be secured—viz. an amount of strength which will obviate any danger of the plate cracking through the centre.

If the imitation of nature be carried far enough to reproduce the rugæ upon the plate, it will be found to be a decided benefit both to articulation and in the management of food in mastication. When the lingual side of the plate is smooth the tongue has but little power to hold a morsel of food upon it, while with the rugæ the food is easily held and managed. They are easily formed by burnishing a piece of heavy tin-foil over a model showing them prominently, filling the depressions in the tin-foil with wax or paraffin, and then fitting and attaching it to the trial-plate when waxed up and ready for flasking, leaving its edges turned up so that it will be held securely in the plaster when the plate is flasked. The surface of the vulcanite will come out clean and smooth, and will require but little polishing. It will be found that a patient who has once become accustomed to the use of a plate made as above suggested will be extremely loath to return to the use of one as ordinarily made.

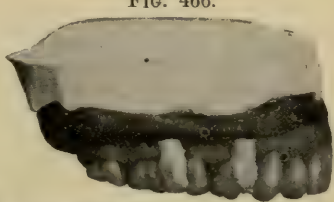
Removal of Cases from the Articulator.

After the teeth are arranged and the waxing is finished, the cast with the wax-plate and tooth in position should be removed from the articulator.

This is done by trimming off the plaster which held the cast to the articulator, exposing the brass bows or frame, and then, by passing the point of a knife or spatula between the base of the cast and articulator, the two pieces will readily separate.

Too much force must not be exerted in this operation, or there will be danger of fracturing the cast. The excess of plaster must now be trimmed from the base of the cast, when the case is ready for *investing*.

Fig. 466.



Showing a plaster cast, with temporary base-plate and teeth in position, removed from the articulator and ready for investing; also the manner of cementing the outside of the joints of gum sections before investing.

CHAPTER XI.

SELECTING AND FITTING THE TEETH; ATTACHMENT TO THE PLATE; FINISHING.

By H. H. Burchard, M. D., D. D. S.

Selecting the Teeth.

If there be any of the natural teeth remaining, these are to furnish the guide for the choice of the artificial teeth. It is noted, first the color of the natural organs, and a sample shade selected which matches them in this particular. Observe the shapes of the natural teeth, whether they be long or short, broad or narrow, thick or slender-bodied—whether the necks of the teeth be narrow or broad as compared with the width of their cutting edges. A mould of teeth is to be selected in which all the features of the natural teeth are reproduced as nearly as possible. It is noted also whether the lip be long or short, and the extent to which the articulating wax is exposed by the movements of the lip.

If the jaws be edentulous, the temperament of the patient is determined by the shape of the arch and vault, by the features, the color of the hair, of the eyes, complexion, etc., as described in the section on temperaments. Teeth appropriate to the temperament are to be selected.

The question of gum or plain teeth is determined first by the amount of absorption; for as the artificial teeth are to replace the lost teeth, so artificial gum is to compensate for deficiencies made by resorption of gum contour. If there be no loss of contour, an artificial gum is manifestly unnecessary.

The material of which the gum restoration is to be made is determined by the exposure or non-exposure of the artificial gum by the movement of the lip. Porcelain gum approximates in appearance the natural gum more closely than artificial gum of any other substance, so that when there is marked exposure of this portion of a denture the porcelain is to be preferred.

There are unsatisfactory limitations as to the amount of arrangement possible with teeth having porcelain gums, so that cases which require an irregular arrangement of the teeth are usually supplied with plain teeth, to which a rim or an artificial gum of one of the vegetable bases is applied.

These several peculiarities and indications are noted when the plate is tried in the mouth and the articulation taken.

The antagonizing models are made, and usually mounted on an articulator. The line on the wax representing the middle line of the face is extended upward and downward by a scratch on the models. At a

point about half an inch above the wax this scratch is intersected by another line; one point of a pair of dividers is placed at the point of intersection, its other point at the line on the wax representing the length of the lip, which is also the length of the teeth, and the distance between the divider points is then marked on the side of the model for future reference.

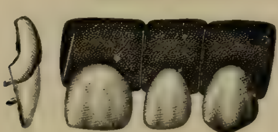
If a full denture, upper and lower, the middle line and the length of the lower teeth are similarly recorded.

The articulating wax having been built to a form restoring the lost facial contour, it is to furnish the guide in setting the artificial teeth in their relation to fulness.

If a full denture, it has been determined by the rules of temperament what should be the size, shape, and shade of the artificial teeth, and a mould is selected from the stock of the manufacturer which best corresponds with the indications.

The shapes of the single gum teeth appropriate to the several temperaments are shown in Figs. 467 to 470. This style of artificial tooth does not offer the same facilities for artistic arrangement that may be made with plain teeth.

Fig. 467.

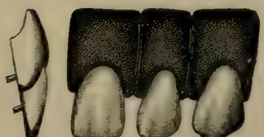


Lymphatic.

Fig. 468.

Sanguine.

Fig. 469.



Nervous temperament.

Fig. 470.

Bilious.

If a single denture or a partial case, the remaining natural teeth serve as guides in selecting the substitutes for the lost organs.

As a rule, the best manufacturers make artificial teeth which bear the relative sizes that are found in the natural teeth. Being copied, in the main, after the natural organs, a mould of teeth which has centrals of the correct size and shape will presumably have lateral incisors accompanying which are in anatomical correspondence, so that in selecting artificial teeth primary attention is directed to the central incisors. It is noted, first, whether the inferior incisors are unusually flat or rounded, whether thick or thin—the superior incisors must be in correspondence; next the width must be correct: as a rule, a superior central incisor is at its cutting edge as wide as an inferior central and half a lateral incisor.

The lengths of the crowns of inferior and superior incisors are about equal, although inferior incisors, through their lesser relative width and by a frequent recession of the gum from the enamel line, appear to be

longer. When set in the proper arch the axis of the superior cuspid should be at the line between the inferior cuspid and first bicuspid.

A shade darker than the natural teeth should be selected in preference to one lighter. The shadow of the lip causes artificial teeth to appear of a lighter color when in the mouth than when held in direct light.

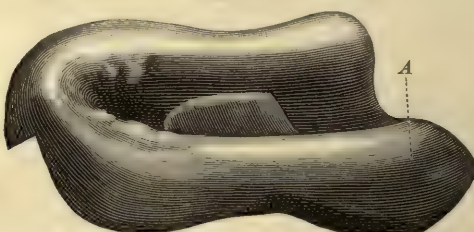
Cuspids are usually more yellow than the incisors or bicuspids: it is advisable to represent this peculiarity in the artificial teeth.

In all cases select well-fired teeth, those in which there is a blending of the point and neck colors.

The lighter gum colors are, as a rule, to be preferred; however, the general colors of the natural gums and of the lips are to form the guide in this particular. It would be obviously an error to place in the mouth of an anæmic patient bright-red or purple gums, and equally wrong to use the light gum shades for a patient who is plethoric and has full, dark-red lips. The gums of blondes are lighter in color than those of brunettes.

After determining and selecting the form, size, and color of the crowns and the color of the gum, the configuration of the latter may form an element in selection, and it should always when block teeth are employed, and may when single gum teeth are indicated. The gum should be thick enough, and yet no thicker than required, to restore the lost contour, and moulds are selected which require the minimum of grinding to adapt them to the indicated degree of contour. Molars and bicuspids are to be selected which shall bring the distal edge of the second molar to about

FIG. 471.



the rise of the tuberosities (Fig. 471, *A*): rarely should that portion of the tooth be beyond the middle of this protuberance. Occasionally it is advisable to omit a tooth from either side to bring teeth of the correct width to the point named.

In selecting teeth for partial cases it is noted first whether there is such a loss of alveolar contour at the site of the absent tooth as to demand restoration by artificial gum. Plain teeth are to be preferred wherever admissible, but lost contour should be restored, so that any marked loss in this particular demands a gum tooth.

Teeth should as nearly as possible match in shade the teeth on either side. If these be pulpless and markedly discolored, their shades differing greatly from that of the vital teeth, they should of course be bleached; but in lieu of bleaching the color of the artificial tooth is to be between that of the vital and that of the discolored teeth. Marked contrasts of color are to be avoided.

It is most important that the shape of the artificial teeth corresponds

with that of the natural organs. It is manifestly improper to place beside a rounded and narrow-necked natural tooth an artificial tooth having a flat grooved face and broad neck.

The cervical line, where the artificial tooth touches the natural gum, should correspond with the cervical lines of the natural teeth.

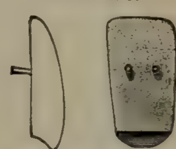
Where a plain tooth which is of the proper length anatomically is found to be too short to extend from the correct cutting-edge length to the natural gum, and when long enough to span the space, sets at a more obtuse angle than the adjoining teeth, an artificial gum is the indication: it should be of a size which shall bring the tooth to the proper angle, and to have the crown of the correct length; that is, in anatomical correspondence with its fellows.

Teeth having their platinum pins in a vertical line (straight pins) are to be preferred to those having the pins in a horizontal line (cross pins), on account of their greater strength. The break in the tooth represented by the pin is the weak spot, and, as the stress upon an artificial tooth tends to fracture it horizontally, it is evident that if both points of lessened resistance be in a horizontal line the danger of fracture is increased.

FIG. 472.

Pins lengthwise.

FIG. 473.



Pins crosswise.

In selecting teeth note that the distance between the plate and the lower pin of the tooth is great enough to permit adaptation of the tooth without cutting away the pin. If this distance is very short, the use of cross-pin teeth will be necessary.

Arrangement and Fitting of Teeth.

If the case be one for the replacement of a full upper denture by single gum teeth, a layer of wax is placed around the alveolar ridge and the tips of the antagonizing teeth are imbedded in it. At its anterior aspect the wax is cut away until it merely serves to retain the artificial teeth when their pins are pressed into it.

The anterior teeth are placed around the incisive arch, so that the amount and direction of the necessary grinding may be noted.

The directions of the axes of the teeth, the lengths and prominence of the cutting edges of the teeth, peculiarities of arrangement, and the spaces to be between the teeth are now determined.

A corundum wheel of coarse grit, one-fourth inch thick by one and a fourth inches diameter, having a round edge, is used for the rough grinding.

The central incisors are to be first adapted. Note the points at which the under surface of the gum touches the plate when the cutting edges of the teeth are placed at their proper length and their proper distance from the tips of their antagonists. Grind the teeth away at these points, and continue the testing and grinding until there is a fair adaptation of these two teeth.

The joint between them is roughly made, outlining the future joint, and leaving sufficient surplus to provide for the finishing grinding. At this stage the central incisors receive their general expression. Repeat

the procedure with the lateral incisors, giving them the relative position to the central incisors suggested by the positions of the antagonizing teeth, or modifying their position or direction according to any unusual formation of the alveolar ridge at these situations. Rough grind now the joints between central and lateral incisors. The cuspids are next partially fitted after the same manner.

The expression produced by these six teeth will determine in a great measure that of the entire denture.

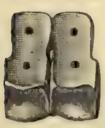
There is not a great latitude of choice for the arrangement of single or any gum teeth which are jointed to one another, so that the prosthetist will find exercise for all his taste and ingenuity in using what there is to the best effect.

If the teeth are of the proper width, the points of the cuspids will now be resting upon the middle of the labial surfaces of the inferior first bicuspids. The amount of joint-grinding necessary to bring the artificial teeth to their correct anatomical positions is now noted. This amount is to be divided among the five joints. If advisable or necessary to leave spaces, it is preferable to make that between the centrals small but distinct. For the final grinding a smaller wheel of fine grit is substituted.

To secure the accurate adaptation of the teeth to the plate some device is employed to show the points of contact between them and to indicate when the contact is perfect. Some prosthetists employ for this purpose small squares of thin carbon-paper pressed against the plate; the tooth, rubbed against this, is marked at the points of contact. A black or blue crayon, used to give a colored surface to the plate, answers well: the writer commonly marks the plate with a blue pencil. The points indicated are ground away until a uniform distribution of the color shows the adaptation of the tooth to the plate to be perfect.

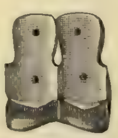
The joint between the centrals is now to be finished. Some operators grind the joints upon the side, and not the edge, of the jointing wheel. A wheel of fine grit about two and a half inches in diameter and perfectly true is revolved rapidly, and the joint surface held lightly and steadily against its side, thus forming a plane surface. The tooth is then set in position on the plate, and the amount of necessary grinding noted in its fellow, which is, in its turn, ground in such a manner that the joint surfaces are in contact throughout (Fig. 474).

FIG. 474.



Faulty joint.

FIG. 475.



Perfect joint.

Great care must be exercised that there be no V-shaped space at the back of the joint (Fig. 474): with close contact of the pink borders anteriorly, or almost inevitably when the teeth expand in heating, the gum will flake.

The writer believes that better joints are made by using the edge of the jointing wheel. Note the points at which grinding is necessary, and, holding the tooth in the thumbs and index fingers of both hands, pass the joint rapidly across the surface of the wheel backward and forward, using a wheel of fine grit having a narrow, square edge. Adjust and joint the other teeth after the same method; and now the points of the cuspids should rest between the inferior cuspids and first bicuspids.

The centrals, if there be any variations in their axes from the vertical line, should point toward, not from, the median line: the laterals, as

a rule, are to be a trifle shorter than the centrals; the cuspids about the same length as the latter. The distal edge of the cuspid is turned in, so that an arc of a circle would be made by the cutting edges of the six front teeth.

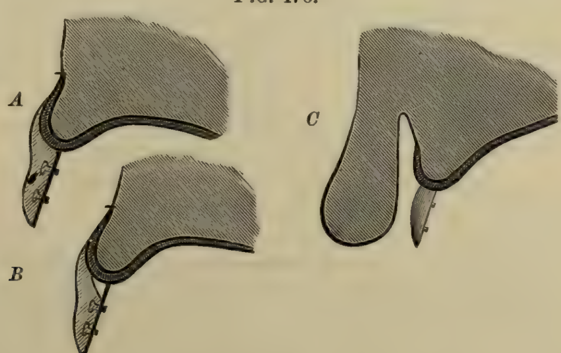
In adapting the posterior teeth, although it is impracticable to carry out Dr. Bonwill's injunctions as to correct occlusion with this type of work, the endeavor should be made to attain two of the objects—to arrange the teeth so that, no matter what the positions of the jaws may be, there shall always be three points of contact between the upper and lower dentures; and to lessen the amount of over-bite progressively to the second molar: these effects are, however, mutually interdependent.

The common fault in arranging the posterior teeth is in making them a portion of a circular arch: the figure should be, including the anterior segment, a parabola. Again, the arch is commonly made too wide across the second molars, thus removing the perpendicular of the teeth too far beyond the centre of resistance, the top of the alveolar ridge, and producing a lessened stability of the piece during mastication.

The bicuspids and molars are ground in pairs, exercising the same care in securing close adaptation of the bases of the teeth to the plate and in making good joints as with the anterior teeth. The joint between the cuspid and first bicuspid requires especial care. The latter tooth should be ground well in, so that it is half hidden by the cuspid. Undue prominence of the first bicuspid is a common fault in the arrangement of artificial teeth.

The bases of all the teeth should rest solidly upon the plate (Fig. 476, *A*), thus bringing the strain upon the bodies of the teeth, and not upon the pins (Fig. 476, *B*), as occurs when the teeth are improperly adjusted.

FIG. 476.



Cases which present a short lip and a full gum contour indicate the use of plain teeth. The thickness of artificial gum necessary to prevent fracture of the latter would cause undue prominence of the lip.

If the natural gum itself is exposed through the movements of the lip and the latter is very full, plain teeth are to be so fitted to the natural gum as to appear to be growing from it (Fig. 476, *C*).

When plain teeth are to be employed, the extent to which the labial edge of the plate is exposed through the movements of the lips is noted,

and it is cut away until it is scarcely visible at the angles of the mouth. Behind this the alveolar portion of the plate is permitted to remain. Usually, the anterior edge of the buccal wall of the plate will then be about between the first and second bicuspids, or a little in front of this point. The necessity for this form of plate has been determined when the impression is taken, so that the minimum of cutting away is required.

The artificial teeth are set in wax and their proper angle to the vertical determined, which is about that made by the lower teeth with the vertical of their alveolar wall. The lingual tips of the upper teeth should be about one-thirty-second of an inch from contact with the lower teeth. The edge of the plate is filed away, so as to support two-thirds the bases of the artificial teeth, the outer third of the latter to be imbedded in the natural gum: the plate is then bevelled to a feather edge.

The central incisors are first ground to the natural gum, next the laterals, and, following, the cuspids, giving to the neck of each tooth the curved outline possessed by natural teeth. When these teeth have been adjusted, a fine point is passed around the neck of each, marking their several positions on the models. Within this line a layer of plaster of uniform thickness is scraped away—about one-thirty-second of an inch if the texture of the natural gum be firm, and more if it be soft—and the necks of the teeth placed in these depressions: the small sections of plate visible between the teeth are removed in the finishing operations. The first bicuspid, whether a plain or gum tooth, is ground so that its anterior edge at the neck also presses into the natural gum. All of the posterior teeth must rest solidly and firmly upon the plate.

The choice of gum or plain teeth to replace the bicuspids and molars is determined by the extent of contour lost: if the loss be slight, the restoration is usually made with pink vulcanite, as this material is much stronger than porcelain for such purpose.

Grinding Partial Cases.

The proper teeth are selected for the replacement of the missing organs, their anatomical forms and sizes corresponding with the natural teeth adjoining. From several samples procured from the manufacturer the teeth best suited in color are taken. This is determined by placing them in juxtaposition with the natural teeth. As stated above, teeth appear in many cases to change shade when placed within the shadow of the lips, and so several are selected, the best of which is determined by the crucial test of placing each in the mouth.

It is preferable, when and where possible, to use plain teeth for partial cases, for when artificial gum is adapted as it should be, its thinness is a decided element of weakness. It is permissible in most cases to make, when necessary, plain teeth a little longer than anatomically correct; but if the loss of gum contour at the site of an absent tooth be pronounced, a gum tooth is indicated.

The teeth are placed on the model, and the amount and direction of the grinding to be done noted. The artificial tooth is in all respects to restore the break in the arch. It is to be ground in until its cutting

edge, the antagonizing teeth permitting, is in the common arch line. The neck of the tooth is to have the shape of the adjoining natural teeth and to be at the same height. The rounded extension of the plate at this point is cut away and bevelled, supporting the base of the artificial tooth and yet hidden by it. If a gum tooth be used, the plate tongue should be larger when possible, affording support to part of the porcelain gum.

To adjust gum teeth the plaster should be colored by means of a crayon or carbon-paper laid under the artificial gum to indicate the points requiring grinding. At the completion of the fitting the plaster should be scraped beneath the artificial gum, so that the latter will press firmly against the natural gum. The artificial gum, to be properly adapted, should exactly restore the contour of the general gum. It is preferable to have too little rather than too great a fulness.

As a rule, it is advisable to have the artificial teeth a trifle longer on the model than the adjoining teeth, or longer than its position should be in the mouth. The yielding of the soft tissues to the pressure of a plate when the latter is in position in the mouth carries the artificial teeth higher than they are on the model, so that, particularly in soft mouths, teeth which are placed in correct anatomical position on a model are too short when in the mouth.

This yielding of the tissues occasionally so alters the relation as to throw out of position the artificial teeth which have been accurately fitted to the model. It is usual in such cases to fasten the teeth to the plate by means of adhesive wax, and accurately adjust them while the piece is in the mouth: the wax softens sufficiently to permit altering the relations of the teeth, which when properly adjusted are chilled, carefully removed from the mouth, and immediately placed in the investment of sand and plaster. In some instances it may be impossible to maintain the relative positions of teeth and plate while withdrawing the piece from the mouth. This is not infrequently the case when the natural teeth are long and irregularly disposed, and single artificial teeth must be set in odd positions with great exactness. It is advisable to have the patient draw the plate well into position, and then take a plaster impression including several teeth on either side of the space for the artificial teeth, in

FIG. 477.

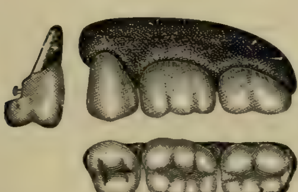
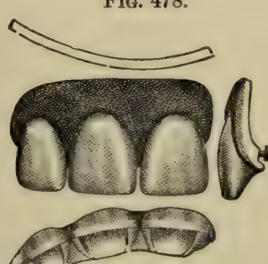


FIG. 478.



which the plate is withdrawn from the mouth. This impression is varnished and a cast made of investing material. When this has set hard it is separated from the impression, and the artificial teeth set in their correct arrangement. Stays are fitted as described below, and additional invest-

ing material placed over and around the artificial teeth, holding them in position, and the model serves as the soldering investment.

Cases in which the investment is made in two sections, as described, require slow and gradual heating to prevent separation of the sections during the soldering operation.

In well-assorted stocks of the manufacturer, blocks of two or more teeth may be found which are well adapted for special cases (Figs. 477, 478). When spaces for which these blocks are designed may be so fitted by them as to restore perfectly the lost contour, they may be employed. They possess the advantage of dispensing with gum joints, but have the disadvantage of greater liability to fracture. They are to be ground to perfect adaptation with the plate, joining the natural gum by a thin edge.

The heads of the pins are cut off, and a stay of plate No. 26 fitted to their backs beneath the shoulders: they are then invested. Great care is necessary in heating and soldering such blocks to avoid fracturing them.

Full Dentures.

To properly adapt, arrange to the best advantage, and to correctly finish a full denture of gum-plate teeth is one of the most difficult operations in prosthetic dentistry.

The articulating wax in its upper and lower sections should represent accurately the length of the upper and lower incisors—the fulness and contour of both dentures. The articulation is mounted and teeth selected which will harmonize in size, shape, and color both of teeth and gums with the age, complexion, and physiognomy of the patient.

In adapting and fitting the teeth to the plates it is usual to regard the lower wax as the outline of the lower denture, this wax remaining on the plate, and the upper teeth are adapted to the plate, as described above, the labial and buccal tips of the teeth following the external edge line of the summit of the wax. After the upper teeth have been fitted, arranged, and jointed in harmony with the physiognomy, they are cemented to the plate by means of adhesive wax. The lower teeth are now fitted to the plate, articulating with the upper teeth.

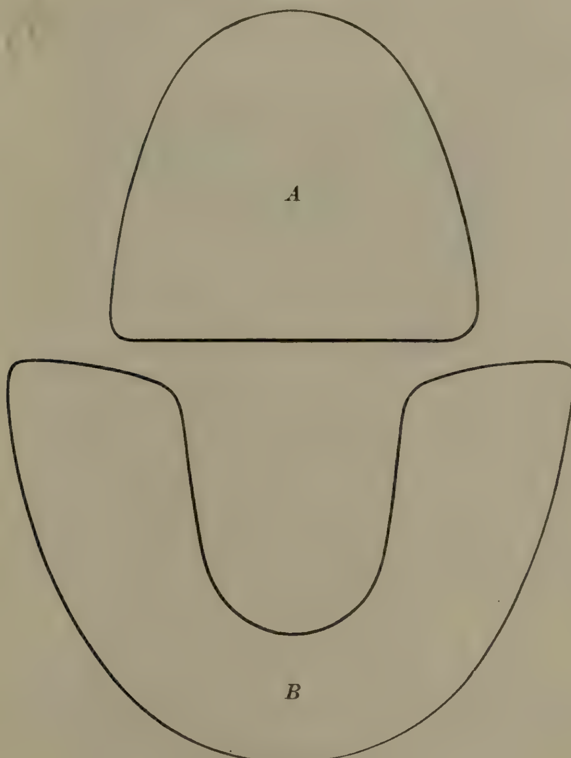
It will be noted in fitting the teeth of lower dentures that, as a rule, the articulating relations existing with the natural teeth are reversed. If the upper teeth have been adapted so as to have a firm plate support beneath, the lower bicuspids and molars when in position are found to occlude not within, but outside, the upper. The reason of this is found in the different manner of resorption of the alveolar processes of superior and inferior maxillæ.

The alveolar process of the superior maxilla diverges from the body of the bone so that during resorption it contracts in the arch areas (Fig. 479, *A*). The process of the inferior maxilla converges so that the greater the shrinkage the wider the arch becomes (Fig. 479, *B*). If teeth are arranged, therefore, in correct anatomical relation in mouths where there has been extensive loss of process, the upper teeth are inevitably placed beyond the centre of resistance, the apex of the ridge, or by narrowing the width of the arch of the lower teeth gives the lingual

wall such an inward inclination that the movements of the tongue are restrained and tend to displace the denture.

Greater stability is given a denture if the bases of both lower and upper teeth rest upon the summits of the respective alveolar ridges.

Fig. 479.



While in many or most cases such an arrangement produces undesirable relations as to the articulation of the dentures, divergence from it decreases the stability of the pieces, so that it is preferable to compromise, giving the tongue as great a latitude of movement as possible without unduly lessening the stability of the denture.

When the arrangement of the teeth is completed, they are to be cemented to the plate for trial in the mouth. This is best accomplished by providing a wall which shall hold the teeth in their respective positions while being cemented to the plate. The surface of the model above the plate line has a series of conical depressions made, usually, three on a side, as shown in the chapter on Block Carving (Fig. 270); these and the walls of the model are varnished and oiled. A plaster batter is applied over the teeth and walls of the model, covering them by a layer about half an inch thick. The plaster wall so made is grooved at the median line, so that it will divide readily at that point. When the plaster has set it is removed in two sections and the teeth

withdrawn from their beds; they and the plate are boiled in the acid solution, then dried. The pins of each tooth are straightened and made parallel: this is best done by squeezing them with a pair of flat-nosed pliers, which will also remove the film of tooth enamel which occasionally overlies the pins. The teeth are returned to their beds, the walls containing them adjusted to the model, and adhesive wax is melted and applied, so that each tooth shall be firmly attached to the plate. The denture is now ready for trial in the mouth.

Trial of Denture.

The plate is placed in position in the mouth, and it is noted, first, whether the joint between the central incisors is in an imaginary line bisecting the face. When the jaws and lips are closed, the edges of the central incisors should exactly mark the length of the lip, except in patients having an unusually short lip, when the teeth may be longer. The occlusion is noted: the teeth of both sides must strike in biting,

The patient should feel no greater pressure upon one side than upon the other. The normal lip outline should be restored; any bulging of the lip shows the gums to be too full: it is rare with gum teeth that the gums are too thin. Teeth unduly prominent or insufficiently prominent should be placed in proper position, and any improvement possible made by altering the positions of the teeth.

The teeth of partial cases are to be pressed into correct positions, so that their necks appear to be growing from the gum. If gum teeth be used, their gums are pressed so firmly against the natural gums as to leave an almost indistinguishable line between the natural and the artificial gum.

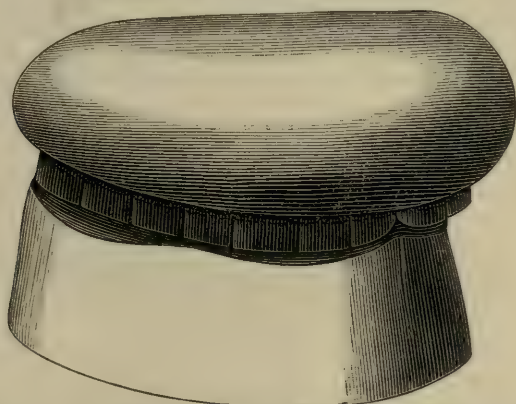
Rimming the Plate.

After the teeth of a full upper denture have been tried in the mouth and found to be correct, a protective rim is to be made extending over the upper edges of the gums for about one-eighth of an inch, and attached to the plate wall above the gums. It is designed to prevent the entrance of foreign substances beneath the artificial gums, and to serve as a preventive against fracture of the tops of the gums. Usually these gum sections are fractured by a fragment of some foreign substance getting beneath the gum and acting as a wedge between gum and plate.

A wall of plaster, as described above, is made, enclosing the teeth, and when hard is removed. Each tooth is loosened in its bed and returned to it. A block of wax is pressed into the lingual surface of the plate, covering enough of the backs of the teeth to hold them in position when the plaster wall is removed. Detach the wall and fill between the block of wax and the teeth with plaster, carrying the latter over the occlusal surfaces of the teeth (Fig. 480). When this block of plaster has set it holds the teeth firmly in their relative positions. The artificial gums are marked by a line at a uniform distance from the upper edge line of the plate. The block of plaster containing the teeth is removed from the plate, and the gums are ground down to the line marked on them, bevelled, and the cut surfaces smoothed on a fine corundum wheel. They are returned to the plate, still held by the block of plaster. The surface

of the model, the upper portion of the plate-wall, the plate heel over the tuberosity, and the gums are oiled and covered by a plaster batter about half an inch thick and extending for more than a quarter of an inch over

FIG. 480.

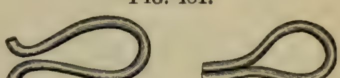


Guide to hold single gum teeth together while adjusting a rim.

the porcelain gums. This plaster forms an impression from which a model of that portion of the denture is to be made. It is a more satisfactory measure to make these impressions in two sections, each of which extends a short distance beyond the median line of the plate. From the models dies and counter-dies are made, two of each for each side.

A strip of plate of No. 28 gauge is swaged between each, and trimmed so that it shall extend for about an eighth of an inch above the plate edge, the lower edge of the strip covering the tops of the gums to a uniform depth of about one-eighth of an inch. The heel of the strip should be closely adapted to the tuberosity and its anterior extremity a short distance beyond the median line. The strip for the opposite side is to be similarly made and trimmed. The plate and strips are boiled in acid, dried, the plate and one strip adjusted to one another with the artificial teeth in position. The strip is to be held by the clamps of iron. The block containing the teeth is removed, and the plate set with its alveolar portion resting uniformly upon a soldering block. A cream of borax is painted along the joint between strip and plate, and two small pieces of solder placed on the ledge formed by the projection of the strip above the plate edge. The plate is now carefully and uniformly heated under the blowpipe, and by means of a fine flame the solder is melted, partially uniting the strip to the plate. When the plate is cool the teeth are set in position to see that the position of the band strip is correct. A line of borax is painted along the lines of junction between the strip and plate, avoiding the introduction of borax into the space to be occupied by the tips of the gum : plate and strip are to be held by means of three clamps—one at the tuberosity, one at the anterior extremity, and one between them. About four of the small squares of solder are usually sufficient to complete the union. The plate is boiled

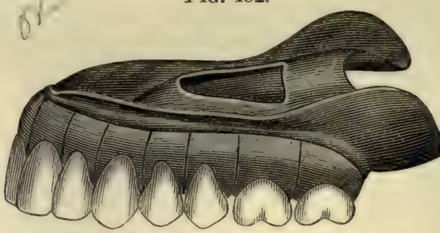
FIG. 481.



in acid, and the anterior end of the strip cut off by means of a saw exactly at the median line.

The second strip is applied to the plate, its anterior extremity cut to make a square joint with the attached half of the band or rim. It is soldered as the first, uniting the ends of the bands by a very small piece of solder. The upper projection of the band is cut down to the plate outline, rounded and smoothed. The teeth are returned to their positions in the plate, and the next operation proceeded with—the fitting of the stays.

FIG. 482.



Upper denture rimmed.

Another but less neat and accurate method of fitting a rim is as follows: Fit to the upper edge of the plate and for an eighth of an inch over the gums of the artificial teeth a strip of pattern tin: this is to be reproduced in plate of No. 30 gauge. Anneal the strip of metal, and fit it to the plate edge and over the artificial gums with approximate accuracy. The plate is laid face upward upon a block of charcoal, and a couple of iron pins pressed into the latter, bracing it against the heel of the plate. The strip is placed in its position upon the plate and held against it by means of two or more iron pins. At the points where it is seen the strip is in contact with the plate borax is applied, and small pieces of solder placed at the points of contact. The parts are then tacked by melting the pieces of solder. Transferred to the model and the teeth placed in position, the contact of the edges of band and plate is furthered, and then soldered, the operations described being repeated as often as necessary to perfect the joint between the plate and rim. The edge of the band covering the artificial gums is burnished down until it is within a small fraction of an inch from contact with them.

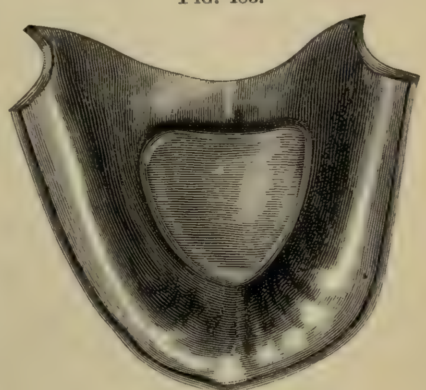
WIRING PLATES.

When plain teeth have been adapted to a plate, and it is designed to place over them an artificial gum of one of the vegetable bases, it is advisable to attach to the upper edges of the plate a continuous wire, to round the upper edge, increase the means of retention of the artificial gum, and to lend additional beauty of finish to the piece. After the teeth have been fitted and tried in the mouth, the palatal line of the base of the last molar is marked by a scratch on the plate. Beginning at the extremity of this tooth, a wire is to curve over the ridge and follow the upper edge of the plate until it terminates at the base of the opposite terminal molar: the stays of these teeth are to abut with the ends of the wire. A piece of triangular wire of No. 18 gauge of the proper length is procured. This is annealed, boiled in the acid solution, and one face of it scraped to exhibit a fresh surface. The middle of the wire

is usually attached first. A clamp holds that point of the wire against the plate at the depression for the frænum, the edge of the wire level with the upper edge of the plate, which is then set on a block of charcoal, the alveolar ridge portion resting upon the surface of the latter. The point of junction of the wire and plate is covered with borax and a small piece of solder placed over it. A fine blowpipe flame is directed against the plate beneath the wire, carefully avoiding contact of the flame with the loose ends of the wire, as these latter fuse very readily. When the solder flows, attaching the wire at this one point, the clamp is removed and the plate plunged in the sulphuric-acid solution. The plate is placed upon the model or die and the wire bent, following the line of the plate. For about half an inch on both sides of the soldered point the wire is brought into close apposition with the plate, the upper edges of wire and plate in a line; the junction is boraxed, a clamp placed at the extremities of the fitted portions of the wire, and joined to the plate by small pieces of solder. The remainder of the wire is, little by little, fitted and soldered until the extremities are attached and are soldered fast to the point at which the disto-palatal corner of the second molar touches the plates. As a final measure the entire length of the joint between the plate and wire is covered by borax, one or two small pieces of solder placed at points where the solder may be deficient in amount, and then the blowpipe flame is passed along the joint, filling the latter completely with the solder.

Should the case be one retained by clasps and not by the vacuum chamber, the wire is to be attached before the clasps are fastened to the plate. Before rimming or wiring it should be determined whether the plate edge is of the proper height or depth, for, should subsequent trimming of this portion of the plate be required, it is possible a portion of the wire might need to be filed away, and thus mar the finish of the denture.

Fig. 483.



Cases which have the third molars remaining should have the wire carried around the plate at the bases of these teeth (Fig. 483).

The wall made over the external faces of the teeth is now cut away at the portions touching the band or wire until the wall is in its proper position. The teeth are set in the wall, the gums in the rim, and they are ready for the succeeding operation.

If the teeth are to be attached to the plate by means of vulcanite the wire is continued across the palatal aspect of the palate, following a line which marks the base of the wax. A pair of special, long clamps will be required to hold the wire in contact with the plate during the soldering operation.

Fitting Stays.

The backing stays which are to serve as the medium of union between teeth and plate are usually adapted to the teeth of partial dentures while they are in the first plaster wall, so that after removal from the mouth the piece may be placed immediately in the soldering investment.

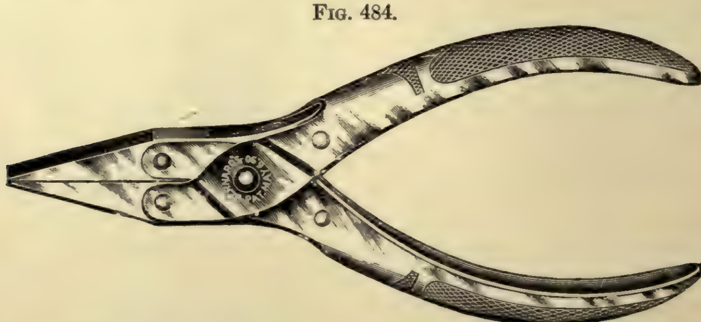
Full upper or lower dentures, or both, when removed from the mouth are set on their models. Should any alterations have been made in the positions of any of the teeth, the gums must be jointed again, so as to restore the continuity of the gum contour. Any slight grinding necessary to perfect the adaptation of the teeth to the plate must also be done.

There are two methods of fitting the stays to the teeth—the first by making a second plaster wall and fitting the stays while the teeth are held in this manner; the second by investing the piece and fitting the stays in the soldering investment. The writer for several years followed the latter method, but has abandoned it for the former, which, although requiring a greater length of time, is more accurate.

After the teeth have been enclosed in the second plaster wall the adhesive wax is picked away, not removed by boiling water, as the latter fills the spaces between and covers the surface of the teeth with a film of the cement.

A pattern in three sections of the stiff foil is made for the stays—one embracing the molars and bicuspids of one side, the second those of the other side, the third of the six anterior teeth. The line of junction with the plate should be accurate. These patterns are duplicated in platinous gold, the thickness of the latter depending upon the amount of stress to which the teeth will be subjected: the usual thickness is No. 25 gauge. For teeth requiring additional support No. 24 to No. 22 should be employed. The outline of the pattern at the line of the junction with the plate should be cut accurately in the gold.

Fig. 484.



Occasionally it will be found that the backs of artificial teeth have a very irregular surface, one to which it would be impossible to adapt the platinous gold as it should be—the surfaces of gold and tooth in contact throughout. This difficulty is overcome by making the stays in two layers, that next to the tooth of thin and pliable metal, 24-carat gold or platinum of No. 32 gauge. The gold when used gives a yellow tinge to the cutting edges of the teeth, the platinum a blue tinge; 22-carat

plate of No. 34 gauge affects the color but little. The gold for stays is first annealed.

The following tools are spread before the operator, so that each may be picked up when required:

A pair of broad-pointed steel tweezers (Fig. 492); the pair accompanying dissecting cases is the correct form;

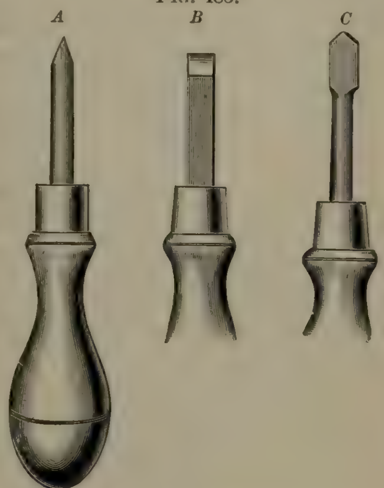
A pair of parallel pliers (Fig. 484);

Two plate-files, one 5 in. long, coarse cut, the other 3 in. long, fine cut;

A pair of plate-punches, a pair being selected which has the shortest distance from the joint to the pin, thus securing the greatest force needed for perforating platinous gold: many punches have the short arm of the punch so long as to require a strong force to perforate the metal;

A countersink engine-bit of about one-eighth edge mounted in the tool handle, for countersinking the holes (Fig. 485, *C*);

Fig. 485.



A chisel having a wedge-shaped edge and mounted in a handle, to split the pins of the teeth (Fig. 485, *A*, *B*);

A small pot of rouge made into a paste with olive oil.

In fitting stays to single teeth, those having irregular backs, the head of each platinum pin is touched with the rouge and oil; a piece of the thin metal is cut the full width and length of the crown and fitted so that it makes an accurate joint with the plate. It is then, while the base is held in contact with the plate, pressed against the lower pin. The position of the latter is marked by the rouge. The pin-punch is placed to cover the mark so made, and the gold is perforated. It is again placed in position behind the tooth, and the second pin marked and the perforation made. By means of a rubber point, the erasing rubber of a lead pencil, the gold is pressed into close apposition with the surface of the tooth. The holes are now countersunk to half their depth from the palatal side. Over the stay so adapted a second stay of platinous gold, No. 27 gauge, is fitted in the same manner. The tooth is now removed from its plaster bed and a sharp point passed around it, marking its exact width and length on the stay, which is then trimmed to this line and given rounded edges. At the cutting edge of the tooth the platinous gold stay is made one-sixteenth of an inch shorter than the other, and given a long bevel. The pins are then cut off to within one-sixteenth of an inch of the stays, and the projecting portion divided into halves by means of the pin-splitter. Care is necessary in this operation that the pins be not shaved away, instead of being divided. The two pin sections are bent back against the stay, and serve to hold it firmly against the back of the tooth. The edges of the stay are given a rounded form, except at the base, set in the walls, cemented to the plate, and the fixture then invested.

In fitting the stays to a full denture it has always been the writer's

practice to begin with the terminal molar of one side, fitting each stay in sequence, so that the second molar of the opposite side is the last stay to be adjusted. Cut from the strip of metal a piece having the width of the base of the tooth. The distal end of the stay for the second molar is made long enough to extend around the gum to the edge of the rim, to which it is ultimately to be attached. If the patterns for the stay pieces are accurate, the section of gold cut by them will fit the plate at the bases of the teeth; if not, the gold is to be filed so that it does fit closely. The pins of the teeth are touched on their ends with the rouge and oil, and the perforations are made as described. Each stay as it is made is cut to the size and form of the back surface of the tooth upon which it is to be placed. The form of the stay for the terminal molar is as represented in the cut (Fig. 486).

The joint between adjoining stays is to be cut square; its base is also to have a square edge. The other outlines are to be bevelled and to follow the form of the back of the tooth, covering it entirely (Fig. 487). The pin-holes are next countersunk.

Fig. 486.

Fig. 487.

The stay for the first molar is cut and fitted in the same manner, making a close joint with the gum portion of the stay of the second molar. The stays for the bicuspids are similarly fitted, and so on to the terminal molar of the opposite side, the stays being given the forms of the backs of the individual teeth, and extending as far toward the cutting edges as the occlusion will permit, the basal portion of each stay fitting to the plate closely, and its lateral walls in close contact with the stays of the adjoining teeth. If there be spaces between the stays and the teeth, the solder which joins the two frequently draws the tooth from its position when it contracts in cooling. The more accurate the adaptation the less solder is required to unite the parts, hence less likelihood of disturbing the positions of the teeth. The contraction of a mass of solder may also cause an alteration of the form of the plate upon which it is melted.

When all of the stays have been fitted the plaster wall holding the teeth is removed. The teeth, stays, and plate are boiled in the acid solution. The teeth are placed in line before the operator, and each stay set beside the tooth to which it belongs. Each is placed on its tooth, and by means of pliers bent until it fits accurately the surface of the tooth. The pins are next cut off to within one-sixteenth of an inch of the surface of the stay, and split. The split sections are bent back, retaining the stay. Each tooth as it has its stay adjusted and fastened is returned to position in the plaster wall, but not before a fine file is passed over the bevelled edges, smoothing the outlines of the stay to those of the tooth. When all the teeth and stays have been so treated, the walls containing them are placed on the model, and by means of adhesive wax the teeth are firmly cemented to the plate.

Fig. 488.

If the operator chooses to assure himself of greater accuracy or more

thorough attachment of the stays to the teeth, and a better finish to their edges, the teeth and stays are imbedded in investing material, thus: Make two beds of the material, about one-half of an inch thick, in each; seven of the teeth are placed in two rows, exposing the surfaces of the stays, the teeth themselves entirely enclosed in the investment (Fig. 488). When this has set each pin is covered by borax, and above each a small square of 20-carat solder is placed. The investments are now heated in a furnace; next in a charcoal bed under the blowpipe, and when the teeth and stays are made a bright red by the heat transmitted through the base of the investment, the fine flame is turned upon each pin until the solder flows about it, filling the countersink. When cool the teeth are boiled in acid, and each stay smoothed and finished on the polishing lathe. This method ensures accuracy, but the experienced operator prefers to have the soldering of stays to the teeth and to the plate in one operation.

When the cement which attaches the teeth to one another and to the plates has hardened, the plaster wall is removed. It is noted whether each tooth is in its proper position; the jaws of the articulator are brought together, so that it may be seen whether the occlusion is correct. The teeth and plate are now ready for investment.

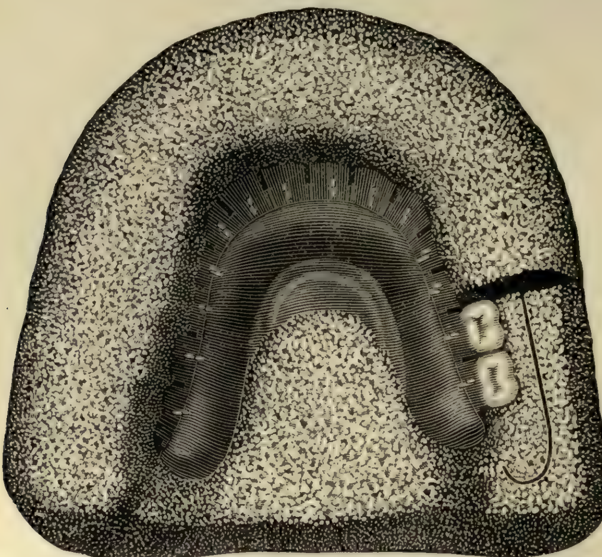
Investing the Case.

An investment is a device designed to hold the teeth and plate in their relative positions during the soldering operation. It is made of a material having a low degree of conductivity and sufficient coherence to ensure that it shall maintain its form when raised to a very high heat. By its relatively low conductivity it prevents too rapid heating of the porcelain teeth which it encloses, and also the too rapid cooling when the source of heat is removed; either of which is a prominent factor in causing fractures of porcelain. The same physical property lends to the investing material the feature of maintaining the teeth at a constant temperature during the soldering operation. Plaster is the basis of the investment; to it are added beach sand and asbestos, so that it will resist fracture in heating.

About a gill of water is placed in a plaster-bowl, and to it are added two tablespoonfuls of short-fibre asbestos. Beach sand is added until the materials are just covered by a film of water, and the mixture is well stirred to distribute the asbestos evenly. Plaster of Paris is next sifted in and stirred until a soft, plastic mass is made. A spoonful of this is placed upon a glass slab, making a layer about half an inch thick. The denture is wet so that the investing material will flow freely into the spaces between the teeth. A small portion of the plaster is taken upon the point of a spatula and worked into the deepest portions of the palatal surface of the plate: little by little, more investment is added until the plate is full, when the material is then packed between the teeth, filling the spaces perfectly. It is then inverted upon the bed of the material upon the slab, and the investment built about the teeth until they are covered by a layer half an inch thick. The lingual surface of the plate is covered to within about half an inch of the bases of the stays. To ensure against fracture of the investment, it is the usual practice to imbed in the investment a piece of round iron

wire. This is bent so that its arch shall be about one-quarter of an inch larger than that of the teeth. It is set in position when the investment

Fig. 489.



Upper denture invested and ready for making the backings, and showing position of wire to guard against fracture.

Fig. 490.

Lower denture invested and ready for making the backings: *A*, position of wire to guard against fracture.

is half completed. When the investment is perfectly hard the cement is picked away piecemeal, every particle being removed. Do not use

hot water for melting out the wax: it is uncleanly, frequently leaving a tenacious film upon the teeth and plate, besides softening the investment.

In some laboratories the teeth and plate after trial in the mouth are immediately invested, and the stay-fitting done while in this encasement, using no preliminary wall. The writer followed this method for some years, but abandoned it for the former method described, that being safer and more accurate. The patterns are made, and each stay cut, fitted, and trimmed as with the method first described. By means of pliers they are bent to fit the backs of the teeth as closely as possible, using especial care that the edges of the stay are in contact with the tooth. The stays are boiled in the acid solution, and their line of junction with the plate scraped clean. Each pin is now cut off to within one-sixteenth of an inch of the surface of the stay and split twice by means of the pin-splitter, the cuts at right angles to one another: the four sections are then bent down, holding upon the stay firmly. Care is necessary in this operation that not enough force be applied to fracture the investment. Some operators grasp the unshortened ends of the platinum pins in the jaws of a pair of pliers, drawing the ends together over the face of the stay instead of splitting the pins. There is more or less danger of splitting the teeth by this method; besides, the cutting of four leaflets and bending them from the centre gives a form to the pin like that of a rivet head: the likeness is complete when the spaces between the leaflets are filled with solder, so that the attachment is a combination of soldering and riveting.

No matter how carefully the stay-fitting may be done by this method, there is not so good an adaptation of stay to tooth as with the first method described. Another objection is that the necessary manipulations tend to loosen, to a greater or less extent, the teeth from their positions in the investment, so that after soldering the alterations of position may become evident.

Dr. W. H. Trueman[1] advises a method for overcoming one of the great defects arising from stay-fitting in the soldering investment—viz. the want of accurate contact between the wings of the stays and the lower portions of the tooth back. Each stay is fitted and bevelled as for plain teeth with straight sides. Narrow pieces of thin platinum plate are cut extending from the top of the gum-joint between the teeth to the plate, and wide enough to be firmly held by the sides of the stay. Before the stays are fastened to the teeth these pieces are pressed across the joints, fitting any irregularities of form which may be present, the stays placed in position in pairs, so that by bending down the pins the sides of the stay hold the platinum pieces firmly in position. When all the stays have been adjusted and fastened small pieces of the stay metal are bevelled to fit between the sides of the adjoining stays, and long enough to hide the platinum: before placing them for soldering the surface of the platinum is covered by borax, the base joints are scraped; the small sections are covered by the flux and placed in position. Should there be any points of imperfect contact between the bases of stays and the plate, the space is to be perfectly filled with small pieces of plate appropriately filed and fitted.

Very long teeth, those subjected to unusual stress in mastication, and which might exhibit a tendency to bend at the plate joint, are given the

[1] *American System of Dentistry*, vol. ii.

additional rigidity necessary by placing at the base of each joint a section of triangular wire. A cream of borax is applied to all the joints and about each pin. Solder is cut into small squares of about one-sixteenth of an inch size and covered with borax. Above each pin and over each lateral joint one of these squares is placed. At the base of the stays a continuous line of the pieces is placed on the plate. This amount of solder should suffice to solder a denture if the stays have been accurately fitted and spaces or weak joints correctly buttressed by means of additional plate.

The following rules are to be observed in soldering;

When two pieces of metal are to be united by solder their surfaces should be as nearly as possible in perfect contact.

The solder used for dental appliances should be employed merely as a uniting agent, and beyond the amount necessary to perform this office it should form no part of a fixture. Any additional strength of the piece should be derived from additions of plate, not of solder.

Absolute chemical cleanliness of the surfaces to be united is necessary, for soldering is a molecular union of the surfaces of metals by means of a metal of greater fusibility than those to be united, and any substance interposed between the metallic molecules prevents their intimate union.

The thickest part of an investment is to receive the greatest volume of heat.

Solder flows toward the parts of highest temperature, so that in soldering the part into or over which solder is to be flowed is made hotter than its surroundings.

The nearer a metal is raised toward its melting-point, the more its molecules separate, and it tends to assume a crystalline structure; therefore the higher the melting-point of the solder used, the stronger is the union of the solder with the soldered metals, and the tensile strength of the latter is correspondingly lessened.

With decrease in the thickness of the solder pieces there is an increased surface of oxidation.

Solder should be placed at short intervals on the part of the fixture most difficult to heat.

Drying of the investment should precede the heating of it.

No tooth should receive the direct flame of the blowpipe until it is heated to redness by heat transmitted through the investment from the exterior.

Borax must not be placed on porcelain: it forms a contractible glass surface which in contracting produces enamel fracture.

In any piece where there may be several soldering operations begin with a high-carat solder—18-carat solder for 18-carat plate—the second soldering with 16-carat, and if a subsequent one be required, 14-carat. This is not necessary where the heat required for fusion of the second solder is at a distance from the solder first fused.

Heating and cooling should be gradual.

The case is now set in the base of an old vulcanite flask and placed on a furnace, and warmed until the investment is perfectly dry: the heat is gradually increased until the base of the investment is red hot. Transferred to a Fletcher furnace, the heat is increased until the entire piece is at a low red heat. While the last stages of the furnace-heating are in progress a soldering-pan is filled with small pieces of charcoal and heated

under a blowpipe (Figs. 68 and 71). The case is transferred to the bed of charcoal, the pieces of the latter being heaped about the sides of the investment. The broad blowpipe flame is then thrown beneath the investment and passed rapidly over its outer wall, until the teeth and stays are made red by the transmitted heat and the solder begins to settle. The fine flame is now thrown upon the line of junction between the stays and plate, and carried from the terminal molar of one side to that of the other, the solder melting and flowing freely. Usually the solder above the pins and lateral joints is fused by the same flame; if not, if it do not flow freely about the pins and between the joints, a very pointed flame is directed at each pin and joint. To flow as it should the solder exhibits a quick fluidity and has a smooth, even surface at the completion of the operation. The case is now returned to the warm tray and permitted to cool slowly. When the stays are cooled, this is the test for the proper time of removing the investment; the latter is carefully broken away piecemeal. The teeth and gums are now examined for any possible cracks or checks, as they are more readily seen while the case is dry. The piece is boiled in the acid solution, washed, scrubbed with soap powder, and dried, and then placed on the model.

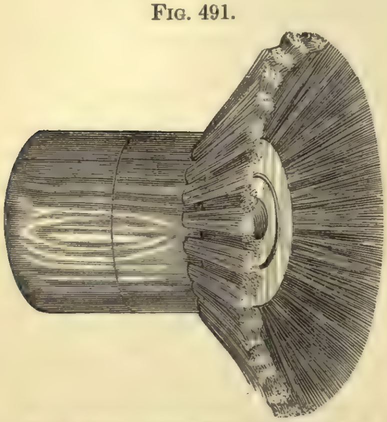
If the preceding operations have all been done correctly, the plate will have suffered no change of form and the porcelain will be intact. If, however, there have been any neglect of the minutiæ, all of vital importance, the plate may be warped, the porcelain gums checked, or one or more teeth cracked or in malposition. If the pieces have been accurately fitted and no excess of solder used, the succeeding operations are a comparatively light task, but none the less important. A small fine corundum wheel on the lathe is used to grind down the heads of the pins and to make uniform the joint at the bases of the backing. A wheel should never be used when and where it touches any point save the one upon which we desire to operate. Flat and half-round gravers (Fig. 291) are employed for the finishing dressing and scraping. The tops of the joints between the stays are given a uniform concavity by means of engine burrs of the plug-finishing variety. The stays themselves and the plate are not to be reduced in thickness at any point: for this reason tools and appliances should never be larger than necessary to remove the superfluous solder.

It is a prudent measure to make a plaster cast of the interior of the plate to support the latter during the trimming and buffing operation: by this means there is a lessening of the danger of bending the plate and of undue strain upon the artificial teeth. Useful points for the smoothing of the surfaces of the stays and their joints are made of old corundum wheels softened by heat and drawn out into flat pencils. By altering the shapes of their points these pencils may be formed so that they may be operated in any irregular places. After all of the surfaces have been dressed smooth, water-of-Ayr stones are used to give the final dressing: they are passed over every portion of the plate surface, obliterating all of the tool-marks and removing the outer coating of the entire plate. "To prevent the entrance of foreign particles in the spaces between the teeth and plate, and between the teeth themselves, the denture may be warmed, and melted paraffin flowed into all interstices: this is permitted to remain, as it effectually prevents the collection of débris

and secretions in parts inaccessible to ordinary cleansing agents" (Bonwill). The piece is now transferred to the polishing lathe, where the smoothing is completed by means of fine felt wheels and powdered pumice.

It is customary with the experienced operator to dispense with the use of Scotch stone, except in places inaccessible to the following implement. Select from the stock of the dental-goods dealer the hardest of the felt cones offered. This is placed on the mandrel of the polishing lathe and revolved rapidly, when a sharp knife-blade held against it divides it into wheels of any desired width. A section of this, three-eighths of an inch wide, is kept constantly charged with powdered pumice made into paste with water, and is passed rapidly across all parts exhibiting scratches or tool-marks. The device is for the removal of slight blemishes, and should never be applied to reducing protuberances. The case is held with the fingers embracing the outside of the teeth and supporting the body of the plate firmly, so that no uneven pressure is brought to bear upon the latter. Plates are occasionally warped during the finishing operation if held improperly. The piece is kept constantly in motion, so that while buffing there shall be no prolonged contact of the wheel at any point. The wheels as they are worn down are preserved for buffing small spaces. When the surfaces of the plate and stays are perfectly smooth, the edges of the plate rounded and freed of all minute irregularities, a brush having a row of stiff bristles is a substitute for the wheel: this is passed rapidly over the surfaces of plate and stays, cleansing well the palatal surface of the former, but removing none of its fine lines. When all the surfaces have received a fair polish by this means, a similar brush is placed on the mandrel, and further surfaced, using a paste of chalk as the polishing medium. Succeeding this, a broad brush (Fig. 97) having fine bristles is employed with the chalk paste, to give a high polish to all of the surfaces—a sufficient finish to render the color of the solder undistinguishable. The plate is from time to time washed to observe the progress of these operations, and, after the buffing with chalk and soft wheel, is scrubbed well with soap to free it from all particles of pumice or chalk.

Fig. 491.



Brush wheel, cup-shaped, for surfacing.

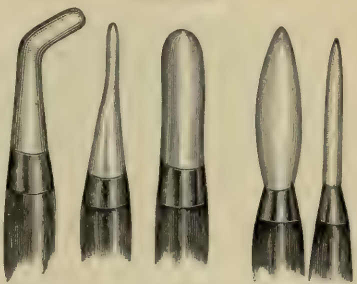
A practice followed by the writer, but which appears to have fallen into general disuse, is to succeed the foregoing operation by that of burnishing.

It is difficult to procure an effective set of burnishers: the best are of small points and edges made of forged steel, the temper scarcely drawn, and given a mirror-like polish (Fig. 492).

A folded towel is placed before the operator and the denture laid upon it, and beside it the burnishers. A block of coarse soap, free

from any grit, and a vessel of water, are set beyond, so that the blades of the burnishers may be frequently lubricated by dipping them first in the water, then rubbing them over the soap. The burnishers are rubbed over every portion of the plate surfaces and stays until a brilliant surface is given them. This operation requires half an hour or more to do thoroughly. At its completion the burnishers are dried and rubbed smooth on a piece of chamois, and returned to a wash-leather wrapping having appropriate pockets for each tool. The case is now washed free from soap, and is ready for the final polishing. The burnishing is commonly dispensed with, and the succeeding operation practised immediately after the final buffing with whiting. A brush four inches in diameter, having the softest of bristles, is employed. A thin mixture is made of alcohol and the finest jeweller's rouge (an oxide of iron): this is painted over the surfaces of the plate and stays, and the brush, revolving as rapidly as possible, is passed and repassed over all parts until the metal portions of the denture have a polish equalling that of the inner case of a watch. Every trace of the polishing powder is removed with soap and water.

FIG. 492.



Burnishers.

An attractive finish may be given the palatal surface of the plate with a water-of-Ayr stone. A piece of this material is filed to a pencil point; the plate surface is wet and the entire palatal surface, except the interior of the chamber, which is highly burnished, is marked by a series of spirals traced by the pencil point, the lines of the spirals radiating from the edges of the chamber: it gives the surface of the plate the appearance of frosting. Any rouge remaining about the joints which is not removable by soap and water may be destroyed by touching the joints with nitric acid, then reapplying the soap. If the burnishing operation have been followed, it will be found that the polish of the plate persists for a greater period.

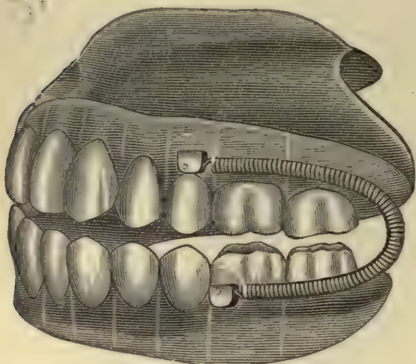
SPIRAL SPRINGS.

Prior to the advent of the vacuum chamber formed in plates, the retaining appliance employed with full dentures was that known as the spiral spring. Improvements in laboratory technique, comprised in better means, methods, and materials for impression-taking, together with a more accurate adaptation of plates, have so limited the use of these springs as to place them in the class of obsolete appliances. It is extremely rare that recourse to this method of retention is ever necessary. Springs are employed only when the anatomical configuration of the parts would render the employment of other retaining devices inapplicable.

Examples of such cases are found when any of the following conditions exist: Extreme flatness of the arch; extreme contraction of the area upon which the plate rests; an exaggerated softness and thickness of the soft tissues of the mouth; or for attachment to obturators or artificial vela in edentulous cleft-palate cases.

The appliance consists of two parts—the springs and the arms to which they are attached. The springs are made of wire coiled about a mandrel, so that they have a tubular form. The arms are in two sections: one section is anchored in the buccal wall of the denture; the other, freely movable upon it by a swivel-joint, is at right angles to the first. There are four of these double arms—one for either side of each denture. The springs are in pairs—one for the right, one for the left side.

FIG. 493.

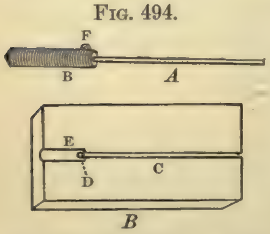


Full denture with spiral springs in position.

The springs are slipped over the free or the movable arms, with the concavity of the spring backward, as shown in Fig. 493. It will be seen that the elasticity of the spring tends to press both dentures in their proper positions. They are so attached that the surfaces of the springs will rest upon the buccal aspects of the denture, and not protrude in such a manner as to irritate the soft tissues of the mouth.

The springs are made of round platinous gold wire, of from No. 24 to 30 gauge, wound upon a mandrel somewhat smaller than the movable anchorage arm. An ordinary knitting-needle will serve as a mandrel. The wire is to be wound in a coil upon this mandrel in such a manner as to have a uniform tension throughout the coils; that is, the spring when completed should be perfectly cylindrical. The springs must be accurately paired: the degree of elasticity in both must be alike. The method of making them, as described by Dr. Wm. H. Trueman, is as follows:[1]

FIG. 494.



Apparatus for making spiral springs: *A*, mandrel; B, portion fitted to lathe; F, loop to which wire is fastened; *B*, block supporting mandrel; C, groove in which mandrel turns; D, hole through which wire passes; E, enlarged portion of groove to accommodate spring wound.

"The mandrel, *A*, is attached to the lathe by its enlarged extremity, B. To support the mandrel when in use a block of hard wood, *B*, two inches long by one inch wide and half an inch thick, is arranged as follows: Lengthwise of the block and centrally located upon its upper surface there is formed a groove, C, in depth twice the diameter of the mandrel and of width sufficient for the mandrel to fit it tightly. From the bottom of this groove and about half an inch from one end drill a hole, D, one-sixteenth of an inch in diameter through the thickness of the block, countersinking each end sufficiently to remove the square edge and round the entrance to the hole at each side of the block. With a small round graver increase the depth and width of the groove from the hole just made to the nearest end of the block, as seen at E. The object of this is that the mandrel may be evenly supported by the

[1] *American System of Dentistry*, vol. ii.

groove in the block when the portion of its length occupying this part of the groove is covered by the wire wound upon it.

"In using this device secure the mandrel in the lathe; the small lathe used for grinding teeth will answer if a stronger one is not available, as the power required is but slight. Pass one end of the wire through the hole in the block and secure it to the loop, F, on the mandrel; turn the mandrel a few times, guiding the wire so that the coils will be far apart: the object of this is, first, to more firmly secure the wire to the mandrel; second, to occupy the space upon the mandrel corresponding to the space between the end of the block and the hole through which the wire passes, so that when the winding begins the wire will be drawn through straight, and not at an angle, as would otherwise be the case. This, a little practical experience will quickly prove, is of more importance than at first appears. We are now ready to begin winding the spring. Place the end of the block through which the wire passes next the lathe-head, the mandrel lying in the groove opposite the centre of and in line with the axis of the lathe-spindle; the right hand should hold the block firmly, and the fingers of the left hand, protected with a glove or a piece of cloth, regulate the tension of the wire by making it bear hard against the side of the hole, D. To make a good spring the wire should be held firmly and with a greater strain than would be prudent with the unprotected fingers. Slowly turn the lathe, increasing the speed if the winding is proceeding satisfactorily, and keep the block firmly pressed toward the lathe-head, so as to lay the coils closely together: the wire forces the block forward on the mandrel too rapidly unless resisted by a firm, steady pressure. There are several points to be carefully guarded in winding a spring. It is all-important that the first few coils should be laid closely together; they are apt to determine the character of all that follow: it may be necessary before proceeding to force them together with a burnisher if they are disposed to separate. See that the wire is not liable to become entangled in the lathe or with near objects, or to form "kinks," as it is very apt to do. By attaching to the free end of the wire a weight of a few ounces this annoyance may be avoided. There is a constant tendency in the coils to ride over those already formed; this must be checked by sufficient tension. If the spring is a long one or if the fingers are insufficiently guarded, the friction of the wire passing over them becomes quite painful, naturally causing the tension to be relaxed and spoiling the spring. The end of the wire, if the wire is completely used up, becomes a source of danger as it passes through the block. It may coil around a carelessly-disposed finger or it may be bent into a hook; in either case it is liable to do serious injury. This will suggest that if a weight is attached to it, it should be secured by tying with a piece of thread that will either slip off or break—never by making a hook or loop in the wire."

The arms are made of 18-carat wire, of a size slightly larger than the tube of the springs. Eight pieces of wire are cut, each about three-quarters of an inch long. Four of these pieces are to be made into movable, four into the fixation, arms. For each of the latter two disks of plate, No. 24, are cut: these are perforated in their centres, so that they shall fit tightly over the wires. One of the disks is driven on the wire for about one-eighth of an inch; the second is then placed at a

distance from the first slightly less than the diameter of the wire. The space on the wire between these disks is to be kept free of the borax with which the lines of junction of wire and disk are touched. An infinitesimal portion of solder is placed outside each disk and fused, attaching the pieces. The external disk is rounded and smoothed; the second is to have a square edge.

FIG. 495.

Button and hook for attaching spiral springs.

The movable arms are made by forming the ends of the wires into loops; the loops are then laid upon a smooth anvil and flattened until they are narrow enough to pass between the disks on the first arms. The loop is opened sufficiently to admit the section of wire at that point.

The sides of the movable arms are squared so that when rotated into the spring tube a faint retaining thread will be formed on them.

As furnished by the manufacturer the arms are undetachable from one another.

If the plate be of metal, an arm is to be soldered to the stays of the artificial teeth; if of vulcanite or celluloid, the end of the wire is bent into a retaining loop. When the plate is of one of the latter materials, grooves or gutters may be formed in its buccal wall to prevent pressure of the spring upon the tissues of the mouth (Fig. 493).

The arms are attached to the dentures in such positions that the springs shall rest upon the buccal surfaces of the dentures. The arms pass between the second bicuspids and first molars of upper and lower dentures. The arms are passed between these teeth until the inner disk rests upon their buccal surfaces. The springs are next placed over the movable arms and pressed against the buccal surfaces of the artificial teeth, when the arms are to be firmly cemented by their projecting ends to the palatal surface of the plate and to the teeth. When the cementing adhesive wax is hard the springs are carefully detached. The position of the arm must not be disturbed in any subsequent operation.

REPAIRING SOLDERED DENTURES.

The common casualties occurring to soldered dentures which demand repair are cracks of the plate, the fracture of one or more teeth, the loss of a natural tooth, leaving a gap in the arch, and, finally, some alteration of the form of the plate.

When cases present for repair, it is always to be noted whether there be any fault in the adaptation of the plate to the arch and vault. Patients by becoming accustomed to the presence of a denture may have their mouths grow tolerant of a piece, the adaptation of which is markedly faulty. Much chagrin is spared the operator if he invariably call the patient's attention to such faults. It may be that the change of form is due to resorption of the tissues of the mouth producing non-adaptation of the denture, or the latter itself may be bent from its original form.

The operator is not infrequently annoyed himself, and unjustly censured for it by patients, by a phenomenon due to physiological processes in the dental arch and vault—to wit: an artificial denture is made and faultlessly adapted; it is worn by the patient for a period ranging from one to several years; then gradually develops a discomfort which an

examination shows is due to lack of adaptation of the plate to its base. When placed upon the original plaster model it is seen little or no change of its original form has occurred. The mouth itself has altered in its configuration, which alteration may be readily demonstrated to the patient by placing the denture upon the model. This is one of the reasons why models should be marked with the patient's name, together with the date of making, and preserved. These changes almost always occur in the mouths of all patients between the ages of twenty-five and fifty years.

In either event, the difficulty complained of being faulty adaptation, it is necessary to again bring the plate surface in contact with the underlying parts. The first step of the operation is the securing of an accurate plaster impression, from which a perfect model is obtained. The latter is given a coating of varnish, and when this is dry the denture is set on the model. If it be a partial case, it will be found, frequently, that it is impossible to place the piece in position on the model without mutilating the plaster teeth. These latter are for the time removed, and the location of the faults of adaptation noted. The most common fault will be found a lateral bending, the posterior angles of the plate bent away from or against the soft tissues of these parts. If this be the only difficulty, the experienced workman readily and deftly restores the form by bending between the fingers. If the difficulty embrace the entire vault or outlined spaces of it, satisfactory readjustment is only possible by reswaging the plate. As a preliminary measure it is advisable to boil all dentures presented for repair in a strong solution of caustic soda or potash, to saponify fatty matters and destroy all food deposits between or beneath the teeth. If this precaution be not taken, the deposits are carbonized during the soldering operation, and blacken the joints by the insoluble and usually irremovable particles. The case is next boiled in the acid solution to free it of the oxides on its surfaces.

A wax-bite is taken and an articulator formed. If it be a partial denture and the bases of the stays are accessible to a fine saw-blade, each tooth is removed by sawing through each stay as close to the plate as possible. Should the teeth be inaccessible to the saw-blade, a small circular saw having very fine teeth is mounted on the lathe and employed for the purpose. In some cases it is necessary to unsolder the teeth from the plate. The teeth and gums are covered by a paste of whiting to a depth of about one-quarter of an inch and the solder surfaces well boraxed. The denture is set over a stove to warm sufficiently to dry the paste when it is placed in a furnace and heated. It is now transferred to a charcoal bed, leaving the teeth and gums free from contact with any pieces which might support them. A blowpipe flame is directed against the encasement until the teeth are at a red heat, when the flame is turned against the plate at the base of each backing, and as soon as the solder is fused each tooth is knocked off the plate and into the charcoal bed, where it is permitted to lie until cool. The plate is cleansed in acid, and the rough solder masses are dressed down by means of coarse files.

The plate is bent into as close an adaptation to the plaster model as possible, between the fingers. The inner surface of the vacuum chamber is oiled, and in it is fitted a piece of wax of the same depth as the chamber

and a hair's-breadth smaller on all sides. In the centre of the chamber area on the model a drop of melted adhesive wax is placed, and the plate containing the wax form quickly pressed into position. In a minute or two the plate is removed and the edges of the wax form are pressed, not melted, into contact with the model; its edges are next smoothed and bevelled, and the entire model is varnished. A die is made, and on it a counter-die of lead, and then one of zinc, are formed. Between the die and lead counter the plate is swaged, interposing between the counter-die and plate a layer of the wet rubber cloth to prevent contamination of the surface of the plate, always more or less rough.

The plate is annealed, and then swaged between the zinc die and counter, when usually it will be found to have a satisfactory adaptation to the model. The teeth are boiled in acid, any ragged edges of solder dressed off, and are adapted to the model and articulator as for a new case. The teeth are cemented to the plate, tried in the mouth, and, if found correct, the piece is invested.

Any space between the bases of the stays and the plate are to be filled with pieces of plate. The surfaces to be soldered are first covered by the cream borax; then in the spaces beneath the teeth and stays a piece of pure gold is placed as a matrix; a fragment of 24-carat plate, No. 36, being bent upon itself, and the folded edge introduced beneath the tooth: the leaflets are then separated, one being brought in contact with the base of the tooth, the other with the plate: the V-shaped depression is filled flush with small bars of plate. The stays and additions are covered by the borax, a greater amount than usual of solder placed on the plate beneath the stay, and the case is heated and soldered as described on the preceding pages.

The next class of repairs in point of extent are those which require the addition of plate to overlie spaces left by the loss of a natural tooth or teeth. A plaster impression is taken of the part with the denture in position in the mouth. The plate is to be withdrawn in the impression. A wax-bite, which has also been taken with the plate in the mouth and before taking the impression, is mounted and an articulation made. If the break in the outline be small and of regular form, a die is not required to fit the additional pieces. The edges of the plate surrounding the break are to be bevelled from the palatal side. If the edges of the break be more than one-sixteenth of an inch from contact with the model, a series of saw-cuts are made along it, extending into the plate halfway to the line of contact with the model. A thin piece of 24- or 22-carat gold plate or of platinum is annealed, and made to conform to the surface of the model by means of the rubber end of a lead pencil: its inner edge is to come within the plate line as far as the end of the bevel, its outer edge to be on a line with the plate line.

A joint made between the plate and the supplementary piece is stronger when the edges of the plate overlap the patch: the adaptation is more accurate, and to secure the necessary strength it is not required to leave an unsightly protuberance. The leaflets between the small saw-cuts are now bent down, covering the added piece. The tooth or teeth are fitted to their places, and stays made. The several pieces are cemented together, and the fixture is invested, making the investment immediately underlying the plate joint thinner than at other places,

so that more heat will be transmitted to this portion of the denture. The cement is picked away, the surfaces well covered by a cream of borax, and in the space between the stay and the plate edge surrounding the break a piece of plate of No. 26 gauge is set, fitting the piece beneath it. Solder is placed around the joints and the case well heated. In the soldering the heat is to be thrown upon the plate beyond the line of the break, so that the solder may be drawn beneath the plate and fill the joint. The deflected heat usually flows the solder about the pins of the teeth and at the base of the stay.

Should the space to receive the addition be large or have an irregular form, it is advisable to swage the piece. The plate edges adjoining the open space are to be bevelled, and the line of the edges traced on the model by means of a pin point. The plate is removed from the model, the latter is varnished, and a small die made of the part to be covered by plate. A piece of plate of No. 26 gauge is swaged to fit, and its inner edge cut down until it is slightly broader than the pin scratch on the model. Saw-cuts are made in the plate edges surrounding the break, and the leaflets bent down, holding the swaged section. The teeth are mounted and the pieces united as described.

Occasionally it is necessary to make the repair in two operations. It may be impossible to perfectly unite the piece to the plate and the tooth to both in one soldering. Such cases are found in those having a portion of the joint between the supplementary piece and the plate extend far beyond the palatal edge of the artificial tooth; for instance, where it is required to add an extension to the end of a lower plate, the additional piece being virtually a small plate covering the ridge. In such cases the piece is first swaged, fitted, and soldered to the plate, and the tooth or teeth mounted in a second operation.

A common casualty, as noted above, is a crack in some portion of the plate. Such breaks are to be repaired by the addition of a strip of plate, never by solder alone. The case is cleansed thoroughly and the edges of the crack are brought together. Should the edges of the crack be separated more than about one-twentieth of an inch, it is inadvisable to attempt readjustment of the edges: the repair is to be made then without any bending. The crack is filled with the cream borax. When this is dry the plate is invested, and a piece of plate of No. 28 gauge, about a quarter of an inch wide and extending the full length of the crack, is fitted to the plate covering the crack. Its upper edges are bevelled, and it is well cleansed, and the surfaces to be united covered by the flux. A piece of solder is laid at each edge, and the case is heated and soldered: in finishing the strip is to represent a rounded ridge. Should the crack be at the portion of a plate embracing the neck of a natural tooth, a semilunar piece is to be fitted over the plate and soldered to it.

When teeth are broken from a denture an impression is taken with the plate in the mouth, an articulation made, the tooth fitted, stayed, and soldered as with a new case.

If the tooth be broken away from its stay and lost, the repair may be made by riveting. A tooth of the same mould and color is selected, the pin-holes drilled, not punched out, as the latter operation invariably bends the stay. The tooth is ground into position: this operation will require some care, owing to the pins hampering the free mobility of the

tooth in its space. If necessary, the pin-holes may be reamed out and made larger. If there be any marked difference in the situations of the pins of the new tooth from those in the old one, the pin-holes are sawn into elliptical openings, and when the tooth is fitted the pins are so bent as to cover as much of the openings as possible. The case is then invested and soldered.

Should the other teeth of the denture be of such type as would be endangered by the heating necessary in soldering, it is advisable to rivet the tooth to the stay. A tooth is selected having the pins at the same distance apart as in the old tooth. The pins of the old tooth are carefully drilled out of the stay, and holes are countersunk at the palatal side. The tooth is fitted to position, and the pins cut off to about one-

FIG. 496.

Riveting hammer.

sixteenth of an inch from the surface of the stay. A folded towel is laid upon an old counter-die, the tooth to be riveted set upon the towel, and no other tooth should press hard against the latter: repeated light blows of a small riveting hammer are directed against the ends of the pins until each is forged into the countersinks, filling them completely and leaving rounded heads, which are then burnished hard to complete the operation.

Cases will occasionally present in which the artificial tooth has broken away from its stay, leaving pins projecting from the back of the tooth about one-fiftieth of an inch long. Such a tooth is to be boiled in a test-tube with nitric acid. To its back is burnished a covering of platinum plate, No. 36 or 38. Apertures are made over the stumps of the pins. The tooth and the platinum back are invested, a piece of pure gold is placed over each pin, and the platinum is soldered to the pins. The old pins are drilled out of the stay standing on the plate. The back of the stay is scraped to cleanse and thin it, and its top bent inward slightly. The tooth with the platinum back is set against the stay and cemented to it: the case is invested, and the platinum soldered to the stay, using a low-carat solder.

In repairing cases having a gum of one of the vegetable bases, if the stay be standing the following method is frequently applicable: The rubber or celluloid is cut out to receive the neck of the tooth, but the festoon covering the latter is to remain untouched. A plain tooth is fitted to the stays, in which pin-holes have been drilled and countersunk. Phosphate of zinc colored pink with carmine is placed in the depression cut in the gum, and the tooth pressed into position: when the cement has set the pins of the tooth are riveted as described.

To properly adjust broken or detached clasps it is necessary to take an impression of the clasp tooth with the plate in the mouth. Should the clasp itself be broken, the surface on either side of the break is filed

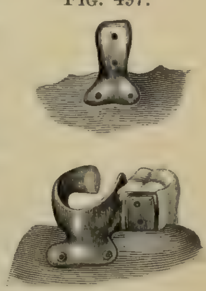
flat and a piece of thin clasp metal extending for one-fourth of an inch on either side adapted, cleansed, and perfectly joined to the clasp by means of solder.

A method of repairing metallic plates without subjecting the denture to the soldering operation, and, what may be more important, a means of attaching a clasp to a plate or an additional tooth without depriving the patient of the piece except for a few minutes, has been devised by Prof. C. J. Essig.

A typical application of the method will illustrate its advantages: A patient is wearing a partial gold plate; one of the remaining natural teeth is becoming progressively looser, and may be lost at any time; it is not permissible to deprive the patient of the piece for the length of time necessary to repair it by soldering. A bite and impression are taken with the plate in position. If the operation be the preparation of an artificial tooth to be substituted for a loosening natural organ, as soon as it is removed; the plaster tooth on the model is cut away, together with an amount of plaster to represent the condition of the soft parts after extraction. A die and counter-die are made, and a piece of plate No. 26 is swaged which shall overlap the plate, as shown on the model, for one-fourth of an inch or more: a tongue to extend into the interdental space is to furnish a support to the artificial tooth. An articulating model is made, a tooth fitted to the model, and a stay adapted to it. The pieces are now invested and united by means of solder, then finished. The edges of the plate piece should receive a bevel, so that there shall be no abrupt line between the new and old plate.

To add a clasp, an impression is taken with the plate in position, and a model is made which shall have a perfect representation of the tooth to be clasped. The clasp is fitted to the tooth, and a piece of plate to the general plate, as described above. This is filed away about the base of the clasp tooth until it has a close joint with the clasp, to which it is cemented, invested, and soldered, and finished as described.

Fig. 497.



To add these pieces to the plate, three holes are drilled through the plate as marked in Fig. 497, and each is countersunk upon its upper side. When, in the first instance noted, the natural tooth is lost, or, in the second, the clasp addition is prepared, the piece is placed in the mouth with the plate itself in position, and by means of a sharp excavator point the outlines of the supplementary piece are scratched on the plate proper. With the pieces held in close apposition a drill is placed through the openings made in the small plate, and the plate proper perforated: the holes are countersunk at the palatal surface. Gold pins upon which rivet heads have been formed are placed through the openings and riveted, thus holding the sections firmly together.

CHAPTER XII.

ENGLISH TUBE TEETH: THEIR USE IN PLATE-, CROWN-, AND BRIDGE-WORK.[1]

By Charles J. Essig, M. D., D. D. S.

English Tube Teeth.

The English tube tooth differs from the ordinary plate tooth in that its attachment to the piece to which it is adjusted is effected by means of a central tube of platinum running through the body of the tooth, and into it a pin or post is introduced (Figs. 498 to 500).

Tube teeth may be used in any situation on either upper or lower plates, and they are well adapted for mastication. Being somewhat cubical in shape, they are probably stronger than flat teeth. The tube tooth is supported over its whole lower surface, and the greatest strain in occlusion falls mostly in a vertical direction, upon the crown and parallel to the line of the central pin; whereas in a flat tooth, the attachment being on one side only, the strain caused by the impact of the bite is more unevenly distributed.

The tube teeth allow of easy removal for repair, it being possible to add a new tooth in from ten to twenty minutes.

As the quantity of solder used in uniting the backings of flat teeth to the plate is of necessity considerable, the danger of warpage from this cause is proportionally great. By the use of tube teeth this risk is entirely removed—a consideration which alone seems sufficient to commend their application in many cases back of the cuspids, where flat-back masticating teeth would otherwise be used.

Many English dentists claim that tube teeth are more adaptable than pin teeth: a very long tooth can be cut down to any length, and the body, being of the same texture throughout, can be ground and polished perfectly.

They can be used for plate-, crown-, and bridge-work, and in some cases in combination with vulcanite. From the ease with which they may be adapted a small stock of these teeth will meet all ordinary demands of private practice—a most important consideration to practitioners who are not within easy reach of a dental dépôt.

Being a more faithful reproduction of the shapes of natural teeth, they are likely to feel more comfortable to the tongue and interfere with speech less than do flat teeth.

They are, in all probability, more easily kept clean, being without backings, which favor the lodgement of decomposable material, than or-

[1] From a paper read before the World's Columbian Congress by John Girdwood, L. D. S. (E. D.), D. D. S. (University of Pennsylvania).

dinary pin teeth, and their supports, being surrounded by porcelain, are out of the reach of any impurity (Figs. 495 to 500).

FIG. 498.
Incisors.
Defective. Improved.

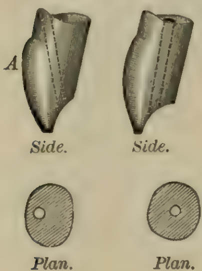


FIG. 499.
Bicuspid.

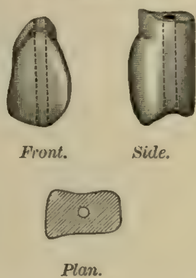
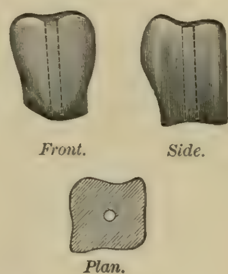


FIG. 500.
Molar.



Defective and improved tubing.

For crown- and bridge-work many advantages are claimed for tube teeth, and those who constantly use them find that they can be as perfectly and directly fitted to natural roots as any other form of porcelain crowns. Being made of porcelain with but a thin central platinum tube baked in them, they retain, when mounted for wear in the mouth, their translucency and natural appearance—qualities so often destroyed by the gold backing on flat teeth.

There seems, however, to be one defect in the tube incisors and cuspids as at present manufactured. In these the base is frequently too small antero-posteriorly, and consequently in many cases it is impossible to cover the root completely with them. Moreover, the tube is very often too near the front, so that the axis of the crown does not always correspond with that of the root (Fig. 498, *A*).

The bicuspids and molars, however, are free from any such faults, and are pre-eminently well adapted for crown-work. Yet with the front teeth as now manufactured good work can be done, and if this style of teeth were in greater demand manufacturers would probably produce improvements beyond those at present thought necessary.

The setting of tube teeth requires the use of a special set of simple hand tools, which are shown in Figs. 501 to 507.

Fig. 501, a countersinker for clearing away the burr which forms upon the end of the tube when ground, and for slightly enlarging the orifice of the tube at its base. A suitable countersinker may be made from an old excavator handle ground to a three-sided pyramidal point and tempered hard. It should be large enough to obviate any danger of forcing it into the tube and so splitting the tooth.

Fig. 502, a tube-file used to remove the débris from the tube after grinding: it follows the countersinker, and is used before trying the tooth on the pin.

Fig. 503, a marker: this is a piece of straight round wire which should fit the tubes easily, but not loosely, and have one end filed almost to a central point.

Fig. 504, a pair of flat-pointed pliers with a longitudinal groove in them for holding the pin while it is inserted in its socket in the plate.

Fig. 505, a sharp-pointed graver.
Fig. 506, a length of gold pin wire (magnified).

FIG. 501.

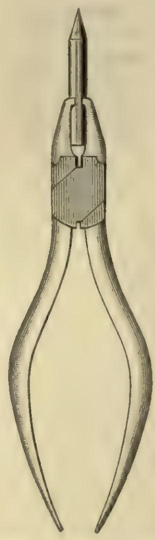
Countersinker.

FIG. 502.

Tube-file.

FIG. 503.

FIG. 504.

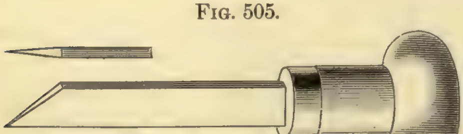


Roughing pliers, with gold pin ready for insertion.

Fig. 507, a pot of paint, not too thin, made by mixing olive oil and vermilion.

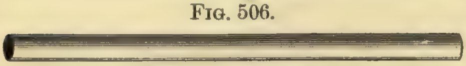
The uses of these instruments will be described in the explanation of the method of mounting the teeth for which they are required.

FIG. 505.



Sharp-pointed graver.

FIG. 506.



Length of pin wire.

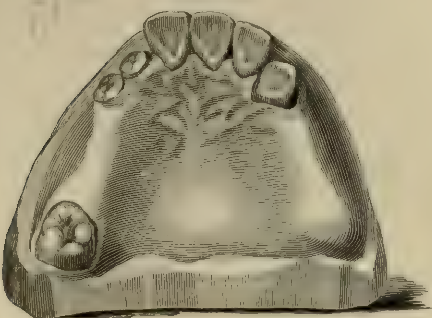
FIG. 507.

Pot of vermilion and brush for marking and fine filling.

Fig. 508. For the purpose of illustration we will suppose a case of a partial gold upper denture, where the lateral incisor and cuspid on the right side and all the grinding teeth on both sides, except the second superior upper molar, are absent. Having swaged and fitted (Fig. 508) the plate in the ordinary way and adjusted the clasp, a tube tooth is selected for each side. Care must be taken that the teeth chosen shall be longer than is apparently necessary, so that there will be tooth-substance to spare in fitting to the plate and bite. The teeth are now roughly fitted in the positions they will occupy. The countersinker removes the burr from the platinum tube at its ground end, and the

tube-file clears out all débris from end to end. The teeth are replaced on the plate to be fastened in their proper positions with hard wax.

Fig. 508.



Model showing standing teeth.

Fig. 509.

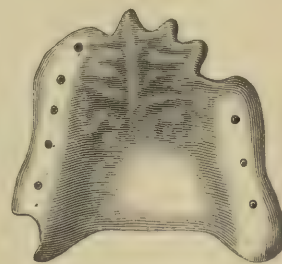
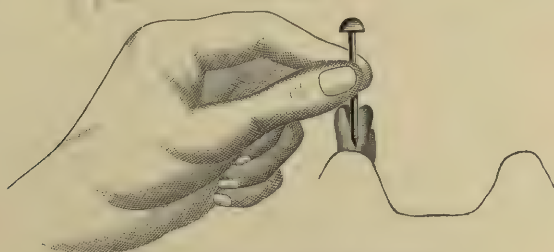


Plate and pins for post teeth.

The marking wire, tipped with vermilion paint, is then passed down each tube till it touches the plate, where it will leave a mark showing the places at which the holes are to be drilled to receive the pins. The teeth are then removed from the plate, care being taken to avoid disturbing the color mark. With a sharp-pointed graver a slight pit is made for the drill. The plate need not be taken from the model while drilling the holes for the pins: care, however, must be observed to keep the drill exactly at the same angle as was made by the marker (Fig. 510). By means of a broach the holes in the plate should be enlarged

Fig. 510.



Showing method of marking pin-posts.

till they are nearly, but not quite, large enough to receive the pin-wire: the rough edge or burr left by the drill must be removed by countersinking both sides. A suitable length of gold pin-wire should then be cut, and the end which is to fit the socket in the plate should be slightly tapered, so as to fit tightly and project about a sixteenth of an inch through on the palatal surface. A slight groove should be made longitudinally on the tapered end of the wire for the purpose of assisting the solder to run more readily from the palatal to the lingual surface. The tapered end of the pin and the pin-hole are then touched with borax, and the wire fixed firmly in place by means of the pliers (Fig. 504), attention being paid to its direction. The tooth is next tried on, and, having ascertained that this particular point is correct, the pins may be soldered in a manner to allow the solder to flow through from side to

side. It is not necessary to invest the plate for this purpose, for the tightness of the pin in its socket will support it sufficiently. In soldering it is of the utmost importance that the smallest possible quantity of solder be used. It will be at once seen that as the tube tooth fits the pin exactly, any excess of solder at its base must prevent the tooth's touching the plate, unless the former be ground out or the superfluous solder cut away. When the plate has cooled, the flux is removed by boiling in water acidulated with sulphuric acid. The projecting end of the pin should then be cut off, and smoothed down with a corundum wheel and graver until it is level with the plate. The plate is then replaced on the model and the pin filed down until they accurately fit the bite. That this shortening should be carefully done is of some consequence, because when the tooth is put in position on its pin it can be seen at a glance how much of its length may be safely ground away in fitting. The teeth are then placed on the pins, and if the latter should have tilted in soldering, it will be at once seen, and may be corrected by grasping the pin close to the plate and bending as required. Now comes the fine fitting of the teeth, done best with small wheels: Paint is placed upon the plate where the tooth will touch it, and the latter is pressed gently to place: when removed it will show a small red mark where it is too long and needs grinding off: having used the countersinker and tube-file, the tooth is to be tried on its pin again, and this process of alternate trying on and grinding is to be repeated until a perfect fit is obtained. It is well in fitting to the plate to remember the bite; otherwise the operator will find, to his annoyance, after having carefully fitted the tooth, that on articulating it is too short. The coronal surfaces of the teeth are now to be ground to suit the occlusion of the bite, using the vermilion paint to ascertain points of undue contact. Next the cuspid and first bicuspid on the right side are set and finished, the first bicuspid on each side serving as a guide: the pins for the remaining teeth may be inserted at one soldering.

Fig. 511.

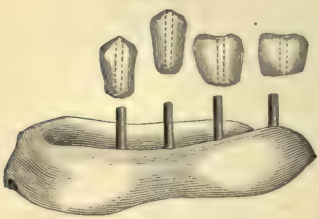
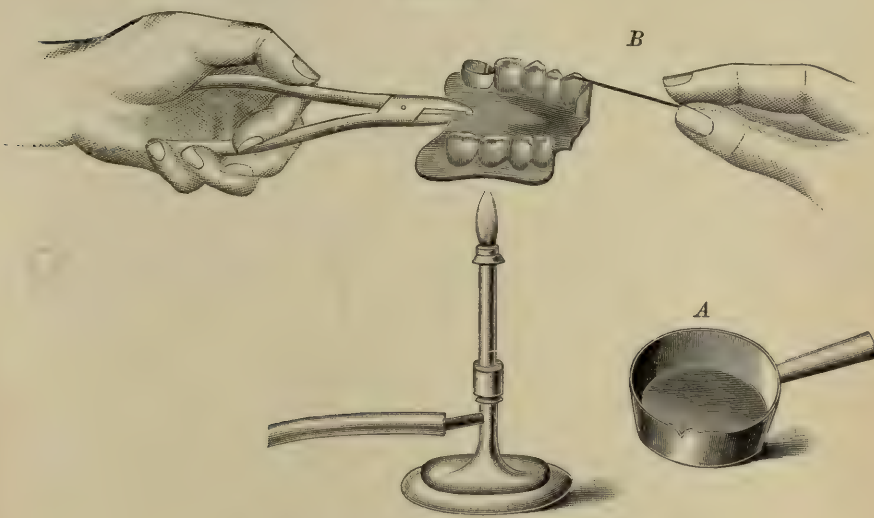


Plate and pins, with little teeth ready for fixing.

Fig. 511. Let us presume that all the teeth have been fitted to the plate and to the bite: their ground edges should then be lightly touched against the side of a very fine corundum or Arkansas wheel in the direction opposite to its motion. The teeth are then polished, and the coronal ends of the pins are finished to show a rounded end or ground to the bite according to the requirements of the case. This done, the plate is finished in the usual manner. Previous to fixing the teeth a few shallow cuts are made in each pin with a fine file. When the teeth have been properly cleaned and freed from all traces of oil—which can be done by boiling them for a few minutes in a strong solution of soda—their tubes are dried by cotton wound round a broach and their interiors roughened by a clean tube-file. Fig. 512 is a good representation of how the tubes are filled with sulphur. This material is melted in the small porcelain Berlin cup marked *A*, until it is quite fluid, and is kept in this condition and held by an assistant. The operator himself grasps the plate firmly

with the pliers (Fig. 512) in the left hand and heats the whole carefully over the lamp. This must be done gradually, and the flame ought not to play on the porcelain. In the right hand he takes the wire spatula

FIG. 512.



Mode of grasping plate in finally fixing teeth.

B (Fig. 512), and, dipping it in the molten sulphur, conveys it to the heated plate and teeth repeatedly till a surplus begins to show itself. The sulphur runs by capillary attraction under the teeth and along their pins, and when the whole has cooled it sets hard and the teeth are immovable. The excess of sulphur may be removed with a fine-pointed knife; the plate is then ready for the final polishing.

This description of the method of fitting tube teeth applies in every particular to all cases, whether they be partial or full, upper or lower. Different methods of setting tube teeth are doubtless practised by different workmen, but it is believed that the modus operandi herein described is as simple and effective as any.

Besides the ordinary tube teeth, single gum teeth of this kind are to be had, and they prove as satisfactory, when judiciously used, as teeth with flat backs. Perhaps it may not be out of place to indicate here the style of case which will prove most suitable to the use of tubes. Mouths where all the masticators have been lost and the front teeth alone remain are very favorable cases for tube teeth. Again, where alternate teeth are missing they answer admirably. They are, however, not well suited for vulcanite work, because from the weakness of the rubber which radiates from the margin of the plate such dentures would be liable to break under the force of mastication. But if a gold plate and tube teeth be constructed for such a case, the ease with which it can be repaired is greatly in favor of its selection; and should the intermediate natural teeth be lost in course of time, other tube teeth can easily be added to the old plate to replace them.

English Tube Crowns.

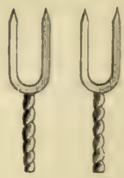
In this country during recent years attention has occasionally been called to English tube teeth in crown-work, although no details of their application have been given. This branch of practice, however, is common enough in England, although the usual method of fitting the tooth to a model, fixing pin and tooth together, and finally cementing them upon the root, is open to many objections—among others, loss of time incurred in taking the model and bite and want of accuracy in fitting.

An improvement in setting tube crowns has been made by Mr. John Stewart, L. D. S., of Edinburgh. The method is as follows: The root

Fig. 513.

Single root pin, with post for tube crown.

Fig. 514.



Bifid root pins, with posts for tube crowns.

is prepared in the usual manner. If part of it remain above the level of the gum, the rubber dam is applied to one tooth on each side before excising, having first anæsthetized the gum by painting on a 20 per cent. solution of cocaine. A ligature is used in preference to a clamp for fixing the rubber, because the latter interferes with the bite when the pin comes to be adjusted. The rubber dam is pushed up as far as possible on the lingual and labial or buccal aspect of the root, for the reason that this kind of crown, being bandless, requires to have its weak point, the union of root and crown, covered by the gum when the dam is taken off. The canal is then enlarged with a twist drill a size larger than the diameter of the wire to be used as a post. If, as often happens in the first bicuspid, the canal be bifid, a piece of wire may be bent, as in Fig. 513, to fit into each canal, and to it the straight post should be soldered; or the straight pin may be "kneed," as in Fig. 514, and an additional "leg" soldered to it. Both ways are practicable, provided the soldering be done securely. The post may be made of gold, platinum, or English dental alloy. The post, where possible, should have a fine shallow thread cut on it, except where it emerges from the root to enter the crown. This part is the weakest, and its strength should not be impaired even by a screw-thread.

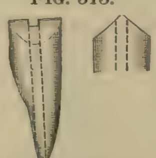
Having selected a suitable tooth, it is fitted roughly to the root before applying the rubber dam. On ascertaining that it fits fairly well, the pin is placed in the root and tried on the crown: if it be much out of line with the other teeth, its position must be corrected, either by bending the pin at the junction of root and crown, or by reaming the canal in the direction necessary, or by a combination of both operations. The tooth and the pin are then tried on once more: if everything is right, the walls of the canal are grooved with a wheel burr; mix the cement, and, placing a little oxyphosphate cement in the canal and around the pin, the latter is forced to its place with the pliers (Fig. 504). While the

cement is still soft the base of the crown is slightly oiled and slipped on to the pin to ensure its correct position before the cement sets. It should be held in place until the cement sets. Then, having taken off the crown, the surplus cement is to be trimmed from the end of the root. This part of the root may, if thought desirable, be cut out around the post and filled with gold or amalgam. This, however, is not necessary except in cases where the root has been much weakened by decay.

The bite will at this point claim attention. The patient is directed to close the teeth, and the post is ground down until it ceases to interfere with complete closure. When no clamp is used, the rubber dam will not interfere to any extent with this part of the work. The tooth is now fitted to the root, as would be done on a plate, but instead of using vermilion paint for fine fitting, a small disk of the thinnest articulating paper, in the centre of which a hole must be made with the rubber-dam punch, is slipped over the pin to the face of the root. The tooth is then pressed to place and ground off where it is marked until a perfect fit is obtained. The articulation is then carefully adjusted. The cervical margin is examined, and if the crown overlap the root, the excess of porcelain is to be removed until the sides of root and crown are continuous. Previous to setting, the base of the crown should be hollowed out, care being taken to avoid the edges: this provides for the presence of a body of cement between the root and the crown, as in the Logan and other crowns. The tube is to be thoroughly cleaned out and roughened in its interior, as in plate-work, and fastened to the pin and root with cement, pressing it firmly to place with a Bonwill crown-setter. The head of the pin may be riveted with an engine-burnisher, and the bite should be examined before the patient leaves.

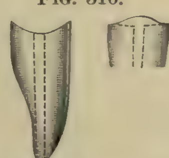
The shaping of the root is a matter of choice. The two which have found most favor are the well-known "new Richmond" (Fig. 515) and

Fig. 515.



New Richmond.

Fig. 516.



Ordinary saddle-shaped.

the "saddle" (Fig. 516) shapes. The crown to suit the former may be fitted by hand with a three-sided corundum file.

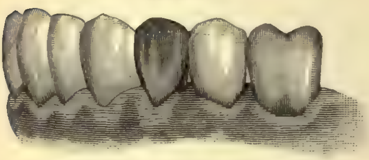
Many suggestions have been made regarding the posts and pins: some operators prefer that they be made of square or oval forms of wire, in order to prevent rotation; but if the roots have been properly prepared, rotation cannot possibly take place unless the crown first becomes loose—an accident which in practice rarely occurs. Besides being unnecessary, square or oval pins are a positive drawback, and they greatly limit the usefulness of this form of crowns. They demand, in the first place, an unnecessary enlarging of the canal, and consequently weaken the root, and as posts they possess less strength than do round ones; and it is sometimes found that after the pin has been set the direction

of the crown is not all that could be desired, or that either the mesial or distal corner stands a little out of line. Where a square or oval post has been used this cannot be corrected, except by the removal and readjustment of the post; whereas when it is round the crown can be turned on its axis in any direction required at any stage of the fitting. For these reasons round posts are generally superior in this class of work to all other forms.

Tube Crowns on Metallic Caps.

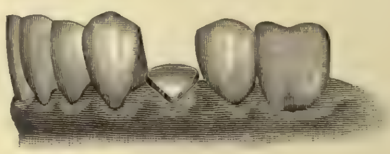
If, for any reason, it is considered advantageous to protect the surface of the root by means of a metallic cap and band, the rubber dam must be dispensed with. The root is trimmed, the sides made parallel, and after fitting a collar to it, leaving the gold a trifle high, the canal is prepared and a post loosely inserted into it. A plaster impression and bite of the whole is then taken. The pin and band will generally come away with the impression, or, should they not do so, they can be easily removed from the root and replaced in the plaster. After running the model, a coin-gold cap, No. 30 thickness, is fitted and soldered to the band: through it a hole is drilled for the pin; it is then placed on the

Fig. 517.



Elevation showing blackened bicuspid.

Fig. 518.



Prepared root.

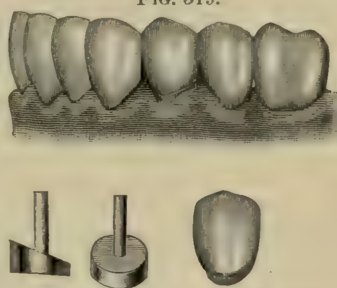
model, the pin is inserted and its direction corrected by bending before soldering to the cap. The pin may be easily bent if nicked with a file, and, as any weakness caused thereby is repaired by the soldering, it in no way imperils the soundness of the post. Having boiled in pickle, the assembled pin, cap, and band are returned to the plaster model, and the crown is fitted as previously described. This done, it is cemented to cap and pin before inserting them in the mouth. This makes a strong and beautiful crown, and, while it is especially applicable to single-rooted teeth, it may also be occasionally employed on some molar roots.

Tube Crowns on Living Teeth.

It is seldom that tube teeth can be used for this purpose, but Dr. Girdwood reports two cases which he treated with gratifying success. Fig. 517 is the first of these, and represents a lower left first bicuspid, which had a large amalgam filling, extending to the crown, on each of its proximal surfaces. The tooth was much discolored, and by its presence the appearance of an otherwise good set of teeth was spoiled. The patient objected to the extirpation of the pulp. The bite was close, yet the teeth showed considerably. An all-gold crown would have been too conspicuous, a porcelain-faced one worthlessly

weak. Therefore, it was decided to grind down the buccal aspect of the root nearly to the gum margin (Fig. 518), leaving the lingual side considerably higher. A cap and band were made to fit the root tightly and to pass a short distance under the gum: a pin was soldered to this and a tube tooth adjusted to it and the bite, and the whole cemented (Fig. 519) on the living root. The buccal side of the 22-carat gold band is almost covered by the gum, and what is seen of it looks like a small cervical filling. The second case reported by Dr. Girdwood does not differ essentially from the first, except that the bite is somewhat closer and the crown, if anything, more severely tested.

FIG. 519.

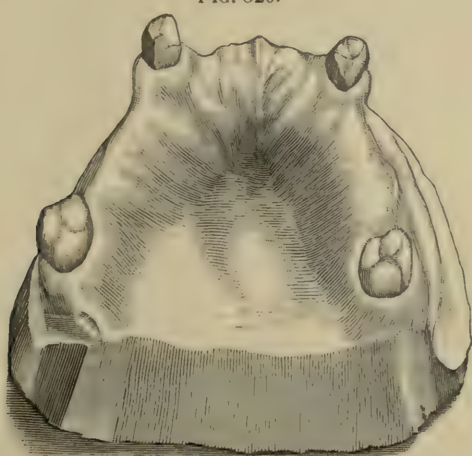


Elevation showing bicuspid tooth.

ENGLISH TUBE TEETH IN BRIDGE-WORK.

As is well known, one of the greatest objections to ordinary bridge-work consists in the difficulty met with in concealing the gold so as not to be seen when the patient talks or laughs. By the use of English tube teeth it is claimed that this objection may be entirely obviated.

FIG. 520.



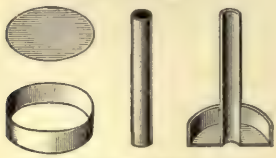
Model for removable bridge.

For fixed bridges replacing the front teeth tube teeth are less suitable, because of the difficulty encountered in securing proper self-cleansing spaces, the *sine quâ non* of the perfect bridge.

The case shown in Fig. 520, where the cuspids are past filling and the molars still stand, will serve to explain the manner of constructing a large removable plate bridge with tube teeth. The crowns of the cuspids are to be cut level with the gum, and the roots prepared after the usual fashion: the canals are to be drilled to receive a gold or platinum

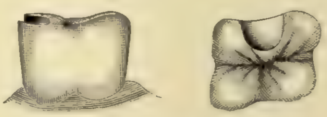
tube, which should be as long as possible and sufficiently wide to accommodate a No. 13 post of hard gold. The molars are next trimmed to receive gold crowns, and a considerable notch is cut in the crown and anterior proximal surface of each. This notch (the object of which will be presently explained) should not extend on the coronal surface more than halfway back, nor on the anterior aspect more than halfway from the crown to the gum. Tubes are then placed in the roots of the cuspids and allowed to project about three-eighths of an inch. An impression of the mouth is next taken in plaster, in which the tubes will come away, and it is run out and opened as usual. The plaster teeth and roots are now trimmed, so that the cuspid caps and molar crowns when made will pass a little way beneath the gum margin. The pattern of cap and band for the cuspid is the "Richmond," and care should be taken that each is made level with the gum on the labial side (Fig. 521). Hard gold or platinum tubes are next soldered to them in lieu of the ordinary posts of single "Richmond" crowns. The fixing of these with cement in their proper positions, and the operation of sealing the apical

FIG. 521.



Cap, band, and tube soldered.

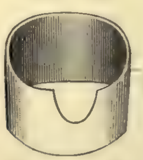
FIG. 522.



Struck crown for molar.

ends with gold or amalgam, complete the preparation of the roots. They are then ready to receive their posts (Fig. 521). A "Mellotte" die of each molar is then taken and a gold collar made to fit it. This collar is notched on its anterior surface (Fig. 523) to suit the corresponding depression on the same surface of the natural tooth; the band is put on the

FIG. 523.



Band for molar.

FIG. 524.

Pure gold cap.

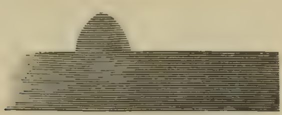
"Mellotte" cast and a piece of No. 30 pure gold (Fig. 524) is placed over the crown and burnished to fit its upper surface and the floor of the notch referred to. When this is soldered to the collar it gives an all-gold crown without cusps. A pure-gold cap is next struck up and filled in with coin gold: it is ground level on its under surface, and is in turn notched at the same part as the gold crown already made. Having adjusted it to the latter, they are soldered together, and an ordinary all-gold crown is the result, plus the recess on the crown and anterior surface (Figs. 522 and 526).

These crowns are cemented upon their respective teeth. Posts with bent ends are now placed in the cuspid tubes and allowed to project from

them about three-eighths of an inch or more. A plaster impression of the whole is now to be taken, and the pins will come away in it if the direction of the cuspid tubes has been carefully considered. Before casting the impression a small piece of metal tubing of such a size as will exactly fit the posts is slipped over each: this will prevent any alteration in their direction when they have to be withdrawn and replaced in their sockets during the making of the bridge.

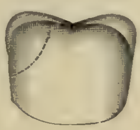
Having cast, opened, and hardened the model, the next procedure is to make the clasps for the fixed molar crowns, as follows: First, take a "Mellotte" die of each tooth and cut a pattern as in Fig. 525, being careful to leave a portion of it (*B*) high enough above the level of the tooth to permit of its being bent down and accurately fitted into the notch. The clasp is next fitted to the tooth, and the portion (*B*) is thinned down with a file and punched till it fits into the depression as

FIG. 525.



Portion of band pattern.

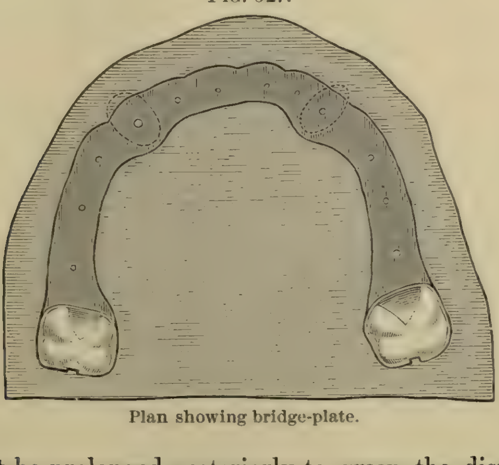
FIG. 526.



Molar crown, notched and completed.

just indicated. It is now strengthened and contoured to the normal shape of the crown by the addition of pieces of hard gold soldered together with 21-carat solder. This forms a strong partial cap or spur, which, bearing on the gold crown, prevents the bridge settling too hard upon the gum. It is better to make the band and spur from one piece of metal, as shown in Fig. 525, than to solder the spur to the band when fitted, for by the former way the continuity of the metal is unbroken.

FIG. 527.



Plan showing bridge-plate.

The clasp must be prolonged posteriorly to grasp the distal surface of the crown, in order that any tendency on the part of the tooth to backward movement by pressure on the spur—which will thus act as an inclined plane—may be prevented (Fig. 527).

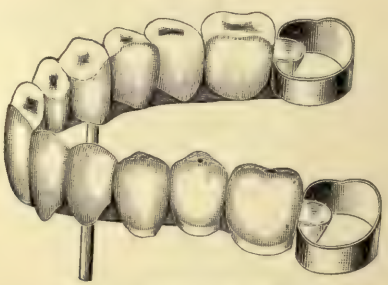
The next step is the swaging of the plate, which is made of two thicknesses of metal, the first being made of No. 24 gauge[1] and about five-eighths of an inch wide all round. It must be stuck up sharply and made to cover the cuspid caps. Next a piece of plate, No. 26 gauge, and a trifle narrower than the first, is swaged over the latter. When fitted the two are soldered together with 21-carat gold solder. The thick single plate thus produced is trimmed to the shape shown in Fig. 456. After having seen that the plate fits, it is drilled through opposite each cuspid tube to receive the posts, which are introduced into the tubes and allowed to project through the drill holes on the lingual surface. The clasps are then adjusted, and a little plaster placed around them and the cuspid posts. When it is hardened the various parts are removed from the model and fixed in their respective places: they are then invested and soldered with 20-carat solder.

If the cuspid tube-tooth posts be thicker than the size of pin wire, they are to be reduced by the file to suit the porcelain teeth.

The teeth are now adjusted as described in their plate application, the finished piece is shown in Fig. 528.

Modification of this method can be used in the construction of any removable tube-tooth bridge. The point to be especially noted is the treatment of the molars, a plan which can be adapted to suit any of the

FIG. 528.



Side view of teeth on bridge-plate.

posterior teeth. It most surely prevents the "settling" of the denture and the tendency to movement on the part of the natural teeth.

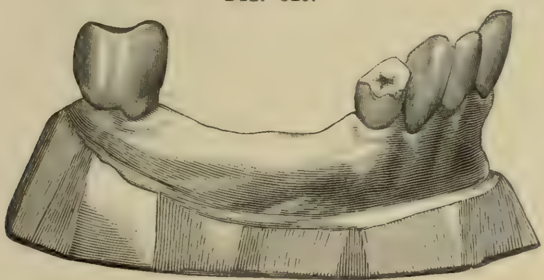
FIXED BRIDGE-WORK.

Fixed bridge-work offers but a limited scope to English tube teeth, for they can, as a rule, be used as substitutes for the masticating teeth only, or, at most, behind the laterals. As already mentioned, the obstacle to their utilization in restoring the front teeth is the much-discussed self-cleansing space, which cannot readily be gotten by any all-porcelain crowns, for reasons which render useless the adaptation of Logan, Bonwill, and other crowns to like purposes. The idea must not be formed, however, that the tube teeth can never be used here; but, on account of the shape of a front tooth which necessitates a short and weak lingual surface, often to be further destroyed to accommodate the bite, it is inadvisable to use them except in the few cases where the bite of the lower

[1] English gauge.

teeth strikes abnormally far in. Here they may safely be applied. Fig. 529 represents the kind of case in which a fixed bridge with English tube teeth answers admirably. The gap in the dental arch extends from the

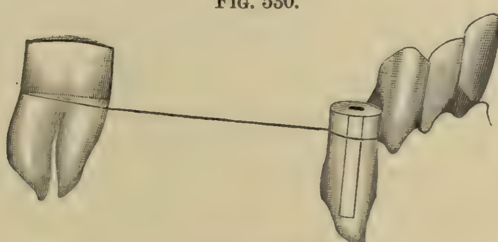
FIG. 529.



Mould for fixed bridge.

third molar to the first bicuspid. The first bicuspid is banded and capped, and a pin which acts as a post both to the root and tube crown is soldered through it (Fig. 530). A gold crown is fitted to the third molar, and a

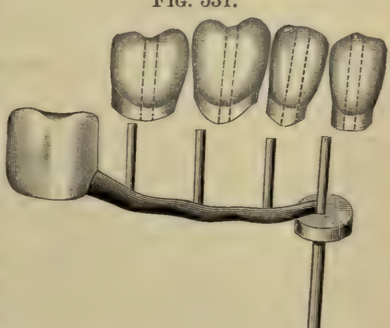
FIG. 530.



Posts trimmed.

strong oval-shaped 22-carat gold bar, which will connect the crown and cap, and ultimately carry the teeth, is made. This bar ought not to rest on the alveolar ridge, but must be about one-sixteenth of an inch from it, and its angle with the alveolar border ought to be as represented in the section shown (Fig. 532, *A–B*). Such a slope downward from the lingual to the labial side will secure a perfect self-cleansing space. The anterior end of the bar must now be soldered, not only to the bicuspid cap, but to the base of the post itself, so that the strain may be borne by both (Fig. 531). So far, then, the bar and bicuspid cap are in one piece, the molar crown remaining unattached. These are to be placed in their relative position in the mouth, and any adjusting made that may be necessary between the molar crown and the posterior end of the bar: they are then taken off with plaster, as described in this operation in

FIG. 531.



Bridge with teeth ready for fixing.

plate bridge, and soldered. A bite must then be taken, and the teeth set up on the bar in the usual way, being fitted to it and allowed to overhang its buccal edge, as represented in the section (Fig. 532). When the teeth have been cemented to place with sulphur, the bridge should be fixed temporarily in the mouth until it has proved satisfactory, when it may be permanently fastened. A fixed bridge like this may be inserted on either side of either jaw, and modified to suit such exigencies as intermediate roots, etc.

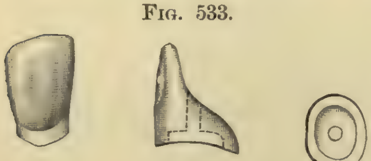
It must not be concluded that the possibilities of tube-work have by any means been exhausted in the descriptions herein given. Their uses seem to be limited by faults in construction of the front teeth, previously mentioned, and shown in Fig. 498, *A*. A porcelain crown has lately been made which is almost identical with the tube tooth herein described (Fig. 533). Speaking of this special crown, Dr. John Girdwood says: "It is made to replace front teeth and bicuspids. The bicuspids are well designed but as much cannot be said for the fronts, for, although the position of the tube has been corrected, the crown is still comparatively worthless, on account of its needlessly weak lingual wall, further undermined in many cases by a too much countersunk base. Because of these, to me, very serious defects, I have never used the new crowns, so I do not on this point speak from experience. Despite their introduction, an improved tube tooth is called for."

Fig. 532.

A point of great moment to the tube-worker is the alloys of gold for posts. In plate-work these are made by English dentists about 18 carats fine. This comparatively poor grade of metal is good enough for plate-work, but in crown- and bridge-work something finer is required. The qualities most to be desired are toughness and non-liability to tarnish, and these can be secured by alloying coin gold with from $1\frac{1}{2}$ to 2 pennyweights of platinum to the ounce: this makes an excellent alloy for all pins, posts, plates, and bars. It is so infusible that it may safely be soldered with coin gold 22 carats fine.

The use of sulphur as an agent for fixing teeth on plates and bridges has long been practised by English dentists, and the question of preference between it and the oxyphosphate cements has been widely discussed by them. Its advocates claim that, except in crowns and other situations where it cannot, from its very nature, be employed, sulphur is much the better of the two materials; which will stand in mouths where from the character of the oral secretion the cements undergo rapid solution, and that none of the oral fluids destroy sulphur. It certainly has the advantage when repairs have to be done. Where cement has been the fixing medium the teeth can only be removed with great force—obviously a very unsafe proceeding. Indeed, if the pin and tube have been well roughened, the teeth cannot be, in many cases, gotten off without fracturing them. By the use of sulphur, however, all this

Fig. 533.



Front. *Side.* *Plan.*

Ash's new tube crowns.

trouble is prevented, for when the plate comes to be repaired it has only to be heated carefully and gradually until the sulphur melts, when the teeth may be easily lifted from their pins and refixed when the repair is effected.

Objection is sometimes made to the appearance of the pins on the coronal surface of tube teeth. This objection may be overcome by cutting as much off the pin as is thought necessary, without impairing its function as a support to the tooth; then cut a piece from a white glass or porcelain rod of proper size in the tube over the pin. This ought to be done before the teeth are finally fixed, so that the section of glass or porcelain will be firmly held by the sulphur. When finished the most critical observer will hardly detect any break in the color of the crowns if the inlays have been well matched.

CHAPTER XIII.

CONTINUOUS-GUM DENTURES.

By Ambler Tees, D. D. S.

The variety of artificial denture known as continuous gum consists of a base-plate of platinum, to which plain teeth are first attached by means of solder, the contours of the natural gum and palatal vault being formed of a porcelain body fusing at a lower temperature than the components of the artificial teeth, over which an enamel closely resembling the gum color is subsequently fused.

Our present conceptions of the work and the methods of its construction are due to the late Dr. John Allen of New York. The principles involved have their authorship traceable to the dental fraternity in France, although their experiments and methods were crude compared with those of Dr. Allen.

In 1815, M. de Chemant obtained a patent for the manufacture of porcelain or "incorruptible mineral teeth." The denture was constructed in one piece; the coloring, to imitate the natural gum, was applied by means of brushes subsequent to the vitrification of the piece. The pigments employed were destructible by the secretions and fluids of the mouth.

In 1818, MM. de Fouze and Delabarre applied jeweller's enamel to the purposes of gum restoration: this was found to crack and flake from the plate. M. Delabarre then conceived the plan of using individual teeth and surrounding them by a porcelain the fusing-point of which was lower than that of the teeth. His experiments were partially successful, but attracted scant attention, and the manufacture of continuous-gum dentures languished until 1846, when Dr. Allen compounded a porcelain body, now in use, for which he obtained a patent in 1851. We are indebted to him not alone for the formulæ themselves, but for methods of design and construction. He first demonstrated the feasibility of restoring lost facial contour.

In comparing the several features of this variety of artificial dentures with those constructed upon other bases, what have been deemed superior virtues have been claimed for it, and certain disadvantages arrayed against it.

It is the most cleanly of all artificial dentures; its plate-base, composed of pure platinum, is entirely uninfluenced by ordinary chemical agencies. There are no interstices in which food débris or secretions may find lodgement and become offensive through subsequent decomposition. Worn for a score of years, the piece when scrubbed is practically as clean as when it came from the furnace.

Any configuration may be given the porcelain body, so that the operator may at will restore to a degree limited only by his taste and skill

any loss of gum or palatal contour. When the palatal aspect of the piece is exposed, its artificiality is not noted, as with dentures constructed upon other bases.

The objections urged against it are, first, its great weight as compared with other artificial dentures. This objection is found to be more apparent than real, for a patient rarely complains of the weight of a properly adapted continuous-gum denture.

Second, it is asserted that the inevitable contraction of the porcelain body causes more or less change of form of the platinum base-plate. Faults in this direction are largely traceable to lack of skill upon the part of the operator: with increased familiarity with this class of work difficulties in the direction named diminish.

The next objection is the liability to fracture: certainly increased care upon the part of the wearer is necessary to avert accidents with a porcelain piece. Fracture occurs usually while the patient is washing the piece: if the precaution is taken to place a folded towel in the bottom of a basin of water and wash the denture while held over the basin, or to use a paper basin, it may drop then without fracturing. Breakage while in actual use very rarely occurs. In 95 per cent. of cases of repair the cause of breakage is that first noted, carelessness in handling by the patient. The writer has seen continuous-gum dentures after twenty-five years of use as perfect and beautiful as the day they were inserted.

One reason adduced for their limited employment has been, the annoyance and difficulty in the operations of attaching the porcelain and enamel. These objections are now largely removed through the improved forms of furnaces employed: with these the work will be found a pleasure. They also remove another heretofore objection—the difficulty and expense of repairing a denture in case of fracture. The electric oven of Dr. Custer makes the operation of repairing continuous gum a mere trifle.

When upper and lower dentures of continuous gum are worn, it is common to find the teeth produce a clicking sound when occluding. The writer has attributed this to faulty adaptation of the lower piece. The intense heat to which a plate is subjected in fusing the porcelain body upon it causes a change of form to the horseshoe-shaped piece of the lower plate, and upon the completion of the operation the two plates are not uniformly supported by their cushions, the alveolar arches. This warpage may be prevented by a means to be described later. This fault is common to all full artificial dentures, upon whatever base they may be mounted, if the same faults of adaptation obtain. To prevent the clicking Dr. John Meyer has suggested that metallic fillings be placed in the articulating faces of the molars.

The term "continuous gum" applies to all pieces in which the artificial gums and teeth are so attached as to form one piece, no matter of what material the base-plate may be constructed; for example, the portion of an artificial denture composing gums and teeth may be made in an arch of porcelain, and this subsequently mounted upon a plate of vulcanite.

Continuous gum is, as a rule, employed alone for full cases, either upper or lower. It is quite possible to construct a partial piece of this material when the teeth to be replaced are in a large and continuous column. Occasionally pieces have been made, and comfortably worn, where the restoration embraced the posterior inferior teeth of both sides.

The Impression.

The physical properties of plaster of Paris recommend it above all other impression materials, although some operators prefer wax or modelling compound for taking the impression of cases which exhibit uneven density of the tissues of the palatal vault. (See Chapter VIII.) The model is made as for any case in which dies are to be formed.

The advisability of a vacuum chamber is a much-mooted question. In cases which exhibit a moderately deep and symmetrical vault a satisfactory adhesion may be secured without the chamber, though a greater adhesion is had where the chamber is employed (Figs. 534 and 535).

Fig. 534.

Showing form of arch where chamber may not be necessary.

The chamber-piece is formed and applied as described in Chapter IX. The plate outline is marked as described in the same chapter: whether for upper or lower case, it must be at such a line, free from impingement upon the movable tissues, as shall ensure against future trimming of the plate edge. A layer of wax about one-eighth of an inch or more thick is built upon the wall of the model as shown in Fig. 535. It is carved to meet the plate line at a sharp angle and as acute as may be consistent with accurate moulding. The wax should exhibit a flat shelf-like surface, which when reproduced in the die, serves to form the upper rim. Special care is necessary in forming the wax for lower dentures, as these plates, owing to a tendency to bury in the gum, are

Fig. 535.

Cast of the upper jaw, with ledge for turning the rim.

carried beyond the original plate outline after being worn for a period. In addition the crest of the ridge in lower cases should receive a film of

wax to compensate for any bruising of the die. The wax wall in lower cases is made continuous, along the entire plate outline, inside and outside.

Across the posterior plate outline for upper cases a wax wall about one-eighth of an inch thick is placed, making the line of junction between the wax and model sharp and distinct: this wax is to join that upon the alveolar line, uniting as the lines pass behind the condyles. When the tissues of the palatal vault at the site of the posterior edge of the plate are soft, it is usual to terminate the plate at its heel, without raising a rim: the latter is then to be formed as described later. The model is now varnished preparatory to moulding.

Matrices are prepared, dies and counter-dies made, as described in Chapter X., using the Hawes flask or cores where and when necessary.

Forming the Plate.

The best specimens of platinum for continuous-gum work are those prepared in France.

Patterns are made of heavy tin-foil (Chapter XI.), allowing a surplus, in the event of the plate shifting position slightly in the die, or to more readily prevent wrinkling of the plate edge. The pattern is reproduced in No. 29 platinum for upper plates. For lower plates two laminæ of metal No. 29 are employed, one large enough to form its borders into a rim, the second, which is to be superimposed, extending to the angle of the rim.

In partial lower cases the body of the plate is to be of No. 29, and to have a supplementary piece of iridio-platinum, No. 26, extending across the lingual wall of the plate behind the natural teeth, and to about one-fourth of an inch beyond the posterior molars.

The platinum is well annealed. The surface of the die is covered with wet muslin, to prevent contact of the platinum with the zinc, and the annealed plate pressed against the surface of the die by the pressure of the ball of the thumb. The plate annealed, the pressure is resumed. The adaptation is now improved by means of the horn mallet, reannealing the plate as soon as it becomes obdurate.

If the operator prefers, he may now employ a partial counter-die to secure primary adaptation of the plate to the vault. The precaution should always be observed of interposing between the surfaces of the plate and those of the die or counter-die a layer of thin wet paper or muslin. Without this medium small particles of zinc or lead may attach themselves to the surface of the platinum, and when the latter is heated the base metal forms an alloy with the portion of the plate upon which it rests. These alloys are very fusible and contaminate the surface, or they may perforate the plate. Indeed, it is well to drop the platinum in hot nitric acid as soon as it is removed from contact with the die or counter-die.

The partial counter-die set in position, and tapped until the vault portions of the plate are in apposition with the die. Removed from the die, the plate is reannealed; the same care exercised to prevent contact of the platinum with the base metals; and the horn mallet is employed to adapt the plate over the alveolar walls. Should wrinkles develop, at the incipiency of their formation the plate is reannealed, and they are removed by

means of the mallet. When the adaptation is fairly accurate the plate is set in the counter-die, beneath and over it a layer of wet muslin: the die is placed in position and the plate is swaged. It is reannealed and reswaged until the adaptation to the die is complete. The surplus plate is cut away by means of shears and files. Should the plate crack or split at any point, a piece of thin platinum is laid over the break and soldered to the plate by means of pure gold. This is the solder always employed with platinum for continuous-gum work. Alloys of gold, as the ordinary solders, containing base metals, exercise a deleterious influence upon the coloring matter of continuous gum. The union of platinum through the medium of pure gold as solder is much stronger than were alloys of gold employed.

Vacuum chambers in platinum base-plates are formed in the plate itself, not soldered to it, as with gold plates. The great heat of the furnace, required to fuse the porcelain, causes wide diffusion of even pure gold through the platinum, so that the minimum of solder is to be applied in this work.

If a second die has been made, the plate is now transferred to it—always a layer of wet tissue-paper interposed, another layer over the plate—the counter-die set in position, and the swaging is completed. The plate is then well annealed.

If a lower plate, the second or strengthening piece is swaged and trimmed, leaving a square edge extending to near the angle of the rim. If a partial lower plate, the supplementary piece of metal is adapted, annealed, reannealed, and swaged until it fits the die perfectly and exhibits no tendency toward alteration of form when heated to a bright red. The upper lingual border of such cases is carried about one-sixteenth of an inch above the plate line. The pieces are held together by means of binding wire and soldered with pure gold.

The plate, thoroughly annealed, is now bound firmly to the die with wire, and by means of pliers and a light hammer the excess of plate extending above the strengthening piece at the lingual aspects of the teeth, is bent over, forming a slight rim not more than one-sixteenth of an inch broad. After the swaging is completed all base-plates for continuous gum should be annealed at a very high temperature.

The adaptation of the plate to the deepest portions of the die is secured through the use of chasers. These are formed of old tooth-brush handles filed to a wedge-shaped edge.

Instead of forming a posterior rim by turning over that portion of the plate, some operators prefer[1] adding to the plate a combination of wire and an addition of plate which shall serve as a limiting shoulder to the porcelain: sloping from the latter there is a ledge of platinum which may, by altering its form, increase or diminish at the will of the operator the pressure of that portion of the denture. Aside from the removal of the abrupt termination of the plate, the added heel subserves another purpose—that of lessening the tendency of the plate to suffer alteration of form when subjected to the great heat of the furnace.

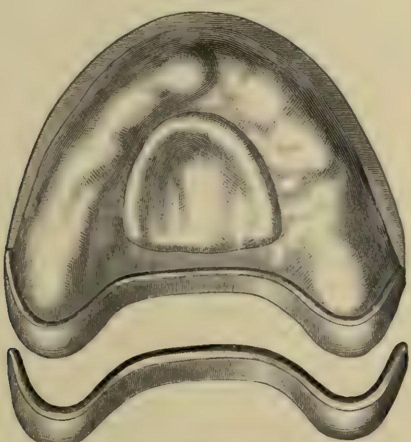
The addition is made after the following method: Round platinum wire of No. 19 gauge is bent to fit the plate along a line extending from the alveolar edge of one side to that of the other, and about three-

[1] Method of Dr. D. D. Smith.

sixteenths of an inch from the posterior edge of the plate. It is first attached on its middle by means of a small piece of 24-carat gold. The adaptation of the remainder of the wire is perfected, and it is attached throughout its length.

A piece of platinum plate No. 29, wide enough to cover the wire and the posterior edge of the plate, and extending the entire length of the wire, is annealed and swaged. It is better to lightly swage the plate with the wire attached before swaging the supplementary piece. As soon as the outlines of the wire are distinctly marked in the counter-die, the groove made in the lead is deepened by means of a chisel. The piece of plate is annealed, laid in position in the counter-die, and swaged. Reannealed, it is again placed in the counter-die, the plate over it, and they are swaged together. The same precaution is taken to prevent the contact of the die and counter-die metals as in swaging the plate proper. The plate extending over the wire and the posterior edge of the plate is cut away until it is flush with the latter and half covers the wire (Fig. 536).

Fig. 536.



Showing piece of plate to be soldered over and back of the wire, and the same in place on the plate.

The sections are bound together, 24-carat gold placed in front of the wire, and heat applied, drawing the solder under the wire and plate addition. The posterior edge is now smoothed and rounded. The plate is next boiled in a 1 : 3 solution of sulphuric acid; then, washed with strong soap, is ready for trial in the mouth and securing of the articulation. It is applied to the plaster model first, to ascertain that its adaptation is correct: if found to be accurate here, it is transferred to the mouth and the patient directed to draw it to position. Should the adhesion be imperfect, a partial adhesion which lessens, the sound of air entering beneath the plate being distinctly audible in some cases, it is first ascertained that the plate is of the proper length—that it does not impinge upon the tissues affected by the movements of the muscles of the soft palate. Should this be found, the disturbing element, the plate, is cut away the proper amount.

Another source of imperfect adhesion will be found in a lack of

accuracy of the adaptation of the plate about the chamber. A sharp edge-graver is passed around the chamber-piece of the die, and a chaser employed to drive the plate into the angle at the base of the chamber.

Occasionally minute perforations may exist in this groove, so that the precaution is taken to partially fill the groove with melted wax.

Should the adhesion be not yet satisfactory, an examination is made to locate, if there be any, hard areas, upon which the plate may be arrested: if none are found and (if present they should have been seen and allowance made for them in forming the model), it is inferred that the impression itself is inaccurate, so that a new impression may be necessary. Should the adhesion be found correct, it is advised by some operators to exercise pressure by means of an excavator at all parts of the plate, and if unusual yielding of the underlying tissues be found in defined areas, the corresponding areas of the die are scraped away and the plate reswaged, until by trial of the plate in the mouth it is found the bearing is uniform. In the majority of cases a plate so adapted to an accurate model that it does not rock when alternating pressure is applied along its crest will require no alterations. These when necessary are to be made by means of burnishers and swaging, never by bending, as the heating of the piece in the furnace neutralizes changes made by bending, and renders them of no avail.

Articulation.

The wax-bite is taken as described in Chapter XII., the wax being built so that it restores the lost lip and cheek contour, the middle line of the face marked, and the length of the teeth represented in the length of the wax. The wax block, thoroughly chilled, is to have a layer of softened wax laid over its end, and the patient instructed to bite until the opposing teeth are checked by coming in contact with the hardened contour wax. A shade tooth is taken, always testing for correspondence in color by placing the tooth under the lip. Should any natural teeth remain, these are to furnish the guide as to the shapes and sizes of the artificial teeth; if all the teeth are absent, the size, form, and color of the artificial teeth are to be determined by the physiognomy, age, and temperament of the patient. As this class of prosthesis represents the acme of dental art as far as plate dentures are concerned, this step of its construction must receive the attention its importance merits.

A distinctive variety of tooth mould is designed for the forming of the teeth for continuous-gum work (Fig. 537). The teeth are made with long porcelain extensions corresponding with the roots; they are designed to ensure the tooth resting upon the platinum plate, no matter what length may be required. Their pins are single, placed beneath the shoulder; they are designed to limit the extent of the artificial gum, and are sufficiently long to serve to hold the tooth to its future backing. When the teeth are to be unusually short, teeth designed for mounting upon celluloid or vulcanite may be employed. The teeth are selected the proper shape, shade, and size, being long enough to extend from the plate to the length marked on the wax, which length has been noted by scratching the model with a pair of dividers.

In selecting the teeth the operator may at will follow any individual

indications of the case in hand: the cuspids may be selected more yellow than the incisors; the shade of a bicuspid may be different from that of the adjacent teeth, etc.

Fig. 537.

Teeth for continuous-gum dentures.

If the models are mounted upon the common hinged articulator, its set-screw is placed at its proper length. If a Bonwill articulator be employed, the posterior portions of the wax are permitted to remain until the anterior teeth have been articulated and arranged.

Any irregularities in the positions of the teeth known to have been present with the natural organs may be reproduced in the artificial teeth. Occasionally the positions and arrangement of the occluding teeth will form a valuable guide in this particular.

The centrals are first set, the amount of grinding necessary to bring the cutting edges of the teeth at their proper lengths, with the artificial roots resting firmly upon the plate, noted and done. The remaining teeth are set to accurate occlusion and arranged in artistic correspondence with the indications. (See Evans' specimens in chapter on Celluloid.)

The forms of these teeth permit a wide latitude in their arrangement, and the operator's taste may make of this and the succeeding operations mere dental carpentry or a fine art.

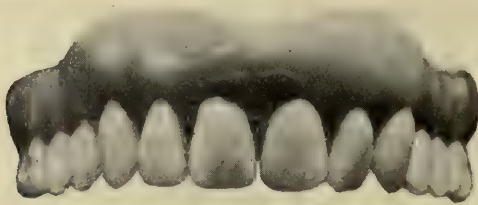
The teeth, after the arrangement is completed, are attached to the plate by means of adhesive wax. Wax is moulded over the buccal and labial walls of the plate, covering the necks of the teeth: it is built and carved after the desired form of the natural gum.

The piece, now placed in the mouth, is to have the articulation tested: if this is found correct, any alterations in the arrangement of the teeth which the artistic sense of the operator may suggest are made. The gum contour is noted: if more wax be required in places to restore the lost facial contour, it is added, and, *vice versâ*, wax is carved away where necessary. The contour of a finishing piece requiring extensive restoration is shown in Fig. 538. The primary wax serves as a guide in forming the contour.

The piece is transferred to the model: the surfaces of the latter and of the wax and teeth are oiled, and a plaster wall formed which shall serve as a guide in moulding the contour of the piece in porcelain. When set this is removed, the wax detached, teeth drawn from their beds, they and the plate boiled in the sulphuric-acid solution. The teeth are returned to the wall, which is then adjusted to the model, and

the teeth are cemented to the plate by means of adhesive wax. When the wax is hard the walls are detached and the articulation tested. The

FIG. 538.



Continuous-gum set finished with plumpers.

surfaces of the teeth to be embraced in the investment are to receive a coating of thick shellac varnish. Owing to the high temperature required to fuse 24-carat gold (the solder), the enamel of the teeth is in danger of fusing with portions of the investment if this precaution of varnishing the teeth is not taken. The shellac burns out in heating, so that a space is left between each tooth and the investment, and their contact is thus avoided.

INVESTING, BACKING, AND SOLDERING.

Investing.—The investing material consists of asbestos and plaster. One part of coarse-ground asbestos is placed in a bowl, the asbestos is covered by water, so that its particles are distinct; plaster is sifted in until the water is saturated, when the mixture is stirred well. The case is wet; the interior of the plate is filled with the mixture; a layer some one-half an inch thick is placed upon a glass slab and the investment in the plate joined to it; the investment is built about, between, and over the teeth to a depth of about an inch. Some operators prefer to add sand to the asbestos and plaster for investing. This lengthens the time necessary for proper heating and cooling, tends to increase the tendency of the investment to fracture, and not infrequently particles of sand fuse to the enamel of the teeth. The writer believes checking and cracking of the teeth to be more frequent with sand than with asbestos as a material for investing.

When the investment is hard, the adhesive wax is picked away from the plate and the teeth, and each pin is bent at a right angle with the axes of its tooth (Fig. 539).

Backing.—Much of the strength of a continuous-gum piece depends upon the proper backing of the teeth. The backing stays for the entire denture are made in three sections—one serving to stay the anterior teeth, one on each side supports the molars and bicuspids.

Patterns are made of stiff paper, following at their inferior edges the outlines of the plate, and fitting beneath the pins of the teeth at its upper edge. The pattern for the stays of the anterior teeth is to extend beneath the pins of the first bicuspids of both sides.

These patterns are exactly reproduced in platinum No. 29, which is well annealed. The anterior section of the stays is adapted first: it is

bent to fit under the pins of the teeth, to conform to the palatal surfaces of their roots, and to be in close contact with the plate at its base.

The pins of the six anterior teeth are now bent over the stay, holding it firmly against these teeth; the pins of the first bicuspids are not bent

FIG. 539.

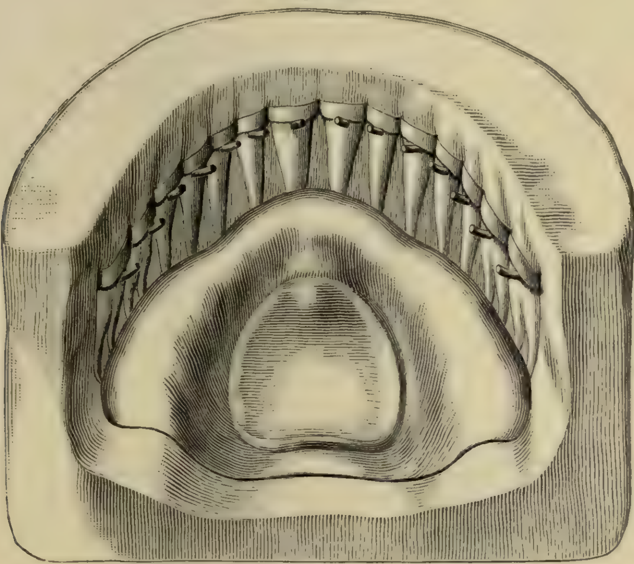


Plate and teeth invested for backing and soldering.

down until the posterior sections of the stays are fitted, when all the pins are bent over, holding the stays. Fracture of continuous-gum pieces occurs perhaps more frequently at the sites of the first bicuspids than in other parts: the double backing at these points will therefore serve to strengthen a weak part.

The writer advises against perforating the stays, as practised in some laboratories: it serves no good purpose, and notably weakens the stays.

Soldering.—Borax rubbed into a paste with water is painted along the junction of each pin with the stay, and along the base of the stays. The borax is applied not as a flux, as the non-oxidizable metals (pure platinum and 24-carat gold) require no flux, but as a means for holding the pieces of solder in contact with the parts upon which they are placed. 24-carat gold of No. 26 gauge is cut in small squares, one for each pin, about one-sixteenth of an inch, the pieces for uniting the stays with the plate about one-eighth of an inch square; 12 grains or but little more of 24-carat gold should be used to solder the piece. A square of solder is laid beside each bent-over pin, and the larger squares set upon the plate at the junction of the stays.

The case is heated, as for any soldering operation, gradually: when the body and walls of the investment are at a red heat the piece is transferred to a charcoal bed and heated until the porcelain teeth and platinum plate are at a red heat, when a pointed flame is directed against the solder, uniting the several pieces. It is to be noted that each pin is perfectly soldered to the stays, adding more solder where necessary.

When the plate and teeth are cool the investment is carefully broken away, and the denture boiled in sulphuric-acid solution until every trace of borax is removed. Borax exercises a deleterious influence in that, if not thoroughly removed, it causes blisters upon the surface of the finished piece. This effect has been attributed to an excess of gold used in the soldering, but after a series of experiments the writer has come to the opinion that the blistering is always due to borax which has been permitted to remain after soldering.

The case is washed with strong soap, then in water, and dried. It is now placed upon the plaster model, to which it should be perfectly adapted; removed to the finishing die if necessary, and coaptation perfected there. The articulation is tested: should any of the teeth have been disturbed in soldering or in removing the investment, they are returned to position. The case is now scrubbed until scrupulously clean, alcohol poured over it, and it is placed where free from the access of even dust.

The subsequent operations relating to the ceramic aspect of this work depend for their success or failure upon the observance or non-observance of technicalities concerned in the management and care of the furnace in which the porcelain is fused, and the methods of attaching and to fusing the three coatings of mineral pastes.

Until within the last fifteen years the difficulty and annoyance of construction of this variety of denture were rightly attributed to the unwieldy furnaces employed and the difficulty of maintaining the correct amount and distribution of heat. The introduction of improved furnaces —first in point of time that devised by the late Dr. Ambler Tees—has lessened the former difficulties, and the substitution of coke for coal as fuel has removed one of the greatest of annoyances, *i. e.* gasing of the porcelain by the ignited gases which find a passage through the pores or cracks in the muffles.

Several varieties and designs of gas furnaces may now be had, which lessen the already lessened annoyance of fire-tending. The introduction of the electric furnace of Dr. Custer removes, when the 52 or 110-volt current can be introduced, the last laboratory objection urged against continuous-gum work.

As coke is almost universally obtainable, the coke furnace will be first described.

The variety used by the writer for several years is that known as the "Tees" lilliput furnace. It is made of fire clay, bound around with strap iron. The furnace is in three sections. The upper section, forming the lid, is perforated in its top for the adjustment of the draught-pipe; in front is a semicircular opening, with a closely-fitting stopper: this is the fuel opening. The second section contains the muffle, its anterior extremity resting upon a ledge, its posterior received into a depression moulded in the surface of the posterior wall of the furnace. The chamber about the muffle contains the greater part of the fuel. The under section contains the grate and the ash-pit. The entire furnace is but fifteen and a half inches high, twelve inches wide, and eight inches deep; the walls are one inch thick. Though the size of the furnace is much less than preceding forms of furnaces, a temperature may be obtained in the muffle sufficiently high to fuse all grades of porcelain.

A special poker and pair of tongs are indispensable adjuncts for the proper management of the fire.

The furnace should be kept in a dry room to ensure against oxidation and consequent destruction of the iron strappings. It is not neces-

FIG. 540.

Lilliput furnace.

sary, as with the old forms of coal furnaces, that the furnace be placed in the cellar to procure sufficient draught: this may be obtained with a much shorter length of chimney.

The furnace is set upon a small table, resting upon bricks placed under its side ends; the back of the furnace is at some distance from the wall. The rim surrounding the chimney opening has placed over it stovepipe which is connected with the wall chimney, as shown in Fig. 540.

PREPARING THE FUEL.

What at a casual glance might appear a detail of small moment is the lighting and maintaining the fire, and yet it is one of essential importance. The pieces of coke should be of a size which shall permit the free circulation of air between them, and yet be small enough to support the heated muffle, offering a large heating surface to the latter. Pieces of white pine, about one inch thick, are cut in lengths of four inches. Selected coke is broken and all pieces chosen about the size of walnuts: about three-quarters of a peck of these pieces will suffice for one heating. The furnace is filled to the top of the muffle with shavings or paper, and some half dozen pieces of wood are thrown upon the shavings, which are then ignited from the top, and the upper stopper is placed in the top opening; enough wood is added to fill the furnace to

the upper opening. When the latter is thoroughly ignited, it is worked well under the muffle by means of the poker, and two shovelfuls of coke are thrown upon the wood. The stopper is replaced and the coke permitted to burn for ten minutes, when the stopper is removed and the coke worked down to the grate, raking out now the ashes and unconsumed wood. An additional shovelful of coke is placed on each side of the muffle and worked well under the latter with the poker. It is necessary that the greatest possible amount of coke should be in contact with the under surface of the muffle to ensure the requisite degree and duration of heat. The body of the furnace is filled to a trifle above the base of the upper opening. The muffle should now exhibit no visible evidence of being heated : it is at this temperature that the case is introduced for the initial heating. The fire is forced by closing the upper opening and removing the draught-stopper at the base.

Each subsequent heating requires a full charge of coke, so that should the furnace be in continuous use throughout the day, the fire is permitted to smoulder until nearly all the coke is consumed, when the ashes are raked away until only a layer of coke remains covering the grate-bars ; over this ignited coke a fresh charge of coke is placed, exercising the same precautions as to its proper distribution as in the first charging.

When the fuel is burnt out and the furnace becomes cool, it is taken apart in the three sections, and all clinkers are removed. It is a general practice to now coat the interior of the furnace with a paste of kaolin and water. A muffle will usually withstand from nine to twelve heatings. Should examination reveal cracks in any part of its length, these are wet thoroughly and filled with the kaolin paste.

The several gas furnaces and the latest development in heating devices, the electric oven of Custer, are described in the chapter on Porcelain.

The Porcelain Paste, and its Manipulation.

The ceramic art in continuous-gum work is divided into three stages of the manipulation of mineral pastes, each of which subserves a definite purpose.

The least fusible mixture is that first applied : it serves as the uniting medium between the teeth and the plate, outlining roughly the general contour of the finished piece. Its degree of contraction is relatively great as compared with that of cooling platinum, so that precautions are taken to neutralize the effect of this contraction.

The second body is employed to remedy defects and deficiencies of the first body and to furnish the contour to the denture.

The third coat is an enamel which when fused resembles the natural gum in color, and presents a smooth, glassy surface.

For the proper manipulation of the porcelain paste and its æsthetic carving the set of spatulas illustrated (Fig. 541) will be found almost indispensable in placing the paste and carving during the several stages of the work.

No. 1 is used in moulding the body and enamel between the necks of the teeth ; No. 2 to carve the festoons and the margins of the arti-

ficial gum; No. 3 for dividing the first coat of body into segments, each having its own centre of contraction; No. 4 for applying and evenly distributing the general body of the enamel.

In the subsequent manipulations scrupulous cleanliness must be observed; the plate and teeth must be entirely free of any particles of foreign materials, even from dust; these if not removed may cause blemishes in the finished pieces. Indeed, it is desirable that the porcelain powders should be made into paste with distilled water.

Fig. 541.

A teaspoonful of the body powder is placed in a small porcelain dish and made into a mixture with water, the consistence of the mixture to be about that of soft putty. In examining the denture in its present stage, if any tooth is short of contact with the plate, small pieces of thin platinum plate are bent and fitted to the spaces; these are to prevent movement of the teeth due to the contraction of the fused body. It has been recommended that the surface of the plate be scratched by means of a sharp excavator point to increase the adhesion of the first coat of body to the platinum; the writer deems this unnecessary.

Small portions of the porcelain paste are taken upon the tip of the spatula and patted into close contact about and between the roots of the teeth: this portion of the body is to be insinuated into all interstices before any attempt is made to apply the labial, buccal, or palatal portions of body; when more body is added, with each considerable addition the edge of the plate is tapped with the handle of the spatula to ensure compactness of the porcelain paste: the excess of water rising to the surface is absorbed by bibulous paper or muslin. The paste covering the lingual surface of the plate should have about the thickness of No. 22 plate. The body is applied over the roots to almost the contour desired in the finished piece; the festoons about the teeth are to be neatly carved and clearly outlined. When sufficient body has been applied and properly trimmed, spatula No. 3 is employed to mark the body into definite blocks, each containing one of the artificial teeth. The spatula is passed through the body until the latter is grooved to the stay and plate; the cuts are continued on the lingual aspect of the denture. Every particle of body is to be removed from about the pins of the teeth. Spatula No. 1 is employed to remove all that portion of body which occupies the groove of the rim; this is done to permit any change of surface which it may be necessary to make in the rim. Each section of body as it shrinks in fusing will have no tendency to disturb the positions of the teeth. The plate, its palatal surface and rim, and the crowns of the teeth are carefully brushed free from any adherent particles of the body. This is accomplished by means of a camel's-hair pencil cut square midway between the ends of the hairs and their entrance to the quill.

First Baking.

The fire, built as described in the furnace, is temporarily checked by removing the upper stopper and inserting the lower one. When the

muffle becomes dark and relatively cool, the denture is set upon a fire-clay slab and placed at the mouth of the muffle, where it is to remain until perfectly dry. If heat is applied suddenly, the body is forcibly detached in flakes and the piece is damaged.

FIG. 542.

Showing piece after first baking.

When the case is quite dry it may be advanced in the muffle until within about one and a half inches from its rear end. The draft is now adjusted, the upper stopper being inserted, the lower removed. When all of the coke has ignited and the muffle itself is seen to be at a bright red heat, the muffle-stopper is applied, and the heat maintained until the body is fused. It is important that this first coating be thoroughly fused, as it is the layer upon which the strength of the finished pieces mainly depends. The several formulas for bodies and enamels vary, and all have different fusing-points: actual test is the only method by which the temperature of fusion may be gauged, so that no general rule can be given as to the length of time a piece is to be subjected to the maximum heat.

After having been subjected to the maximum heat for about ten minutes, the case may be withdrawn from the muffle and examined: if the fusion is incomplete, the piece is returned for about five minutes and again examined. The denture is then removed from the furnace and quickly transferred to a cooling muffle, where it is permitted to remain for about thirty minutes, when it should be cool enough to handle. If upon examination any tooth or teeth may be found to have suffered change of position, it is bent into position by inserting a spatula-blade in one of the lines of division. The porcelain section is to be held in its new position by means of a small fragment of platinum plate wedged under it.

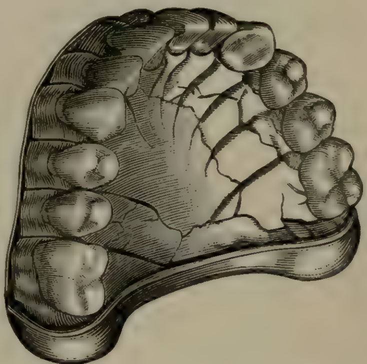
When placed upon the model, should it be found that the plate has suffered any change of form, the usual change being a narrowing of the alveolar portions of the plate, readjustment is effected by using a block of soft white pine across the molars, tapping the wood with the horn mallet until the adaptation of plate to the model is correct. It is to be determined now the extent of bending which shall be necessary to bring the platinum rim at its proper angle. The bending is done by means of a pair of flat smooth pliers and a small riveting hammer as accessory when found necessary. The rim is dressed to a uniform width, using for the purpose small smooth files.

The case, having the appearance represented in the illustration (Figs. 542, 543), is now to receive the second coating, known as the second body.

This layer is to remedy breaks and deficiencies of the first body and to furnish the contour which the third coating, the enamel, sheathes.

An exhaustive familiarity with the several peculiarities of gum outlines and rugæ forms is of extreme utility, as furnishing guides to the æsthetic carving of the second body. The operator should provide himself with typical models of cases illustrating the general forms associated with the temperaments and with the physiognomic peculiarities of persons—what type of gum contour is associated with what forms of teeth, etc. Accurate plaster models of typical cases will be found invaluable in this connection. The forms, sizes, and distribution of the palatal rugæ, anatomical structures, rarely considered in prosthetic dentistry, should be represented in the piece. These structures perform an office in deglutition and enunciation,[1] and should not be ignored. Their presence is found to be a distinct source of comfort to the patient.

Fig. 543.



Shows a case after the first heating.

The paste of the second body is made as the first: all of the cracks in the first body are filled, the spaces about the pins of the teeth are filled, the labial and buccal aspects built out in correspondence with the plaster wall formed over the contour wax (see above). Maintaining the required fulness, the body is to be carved into appropriate festoons. The coating over the lingual surface of the first body is to be thin; the rugæ are to be represented in the second body, defined elevations of the material being placed in their proper positions. After the carving is completed all portions of the denture to which the body is not to be fused are brushed perfectly free of any adherent particles. The fire is to be prepared as for the first heating; the case is inserted as described. The heating of this coat is not to be carried to a state of smooth fusion. It is carefully watched, withdrawn occasionally, and when the surface of the body has an appearance resembling No. 1 sand-paper the case is removed and placed in a cooling muffle for thirty minutes. Should the temperature of the second coating be carried to too high a point, it gives a dull, dead, lustreless appearance to the overlying enamel.

When the case is cool it is placed upon the model, and any faults of plate adjustment are corrected by means of the wooden stick and mallet.

Enamelling.

The mixture for the third coating, that of the enamel, is to be made thinner than for the preceding layers. The denture is first wet to facilitate the introduction of the paste into the crevices of the piece, particularly to ensure its perfect coaptation beneath the rim: this part of the work must be carefully attended to, or else there is danger of the enamel flaking in the furnace. The finer gum outlines are to be restored, the layer of enamel paste to be about the thickness of No. 26 plate. It is

[1] Burchard, *Cosmos*, April, 1895.

made thinner over the portions representing the gum covering of the roots, so that a lighter shade will be shown at these parts, this being in consonance with the appearance seen in the natural gum.

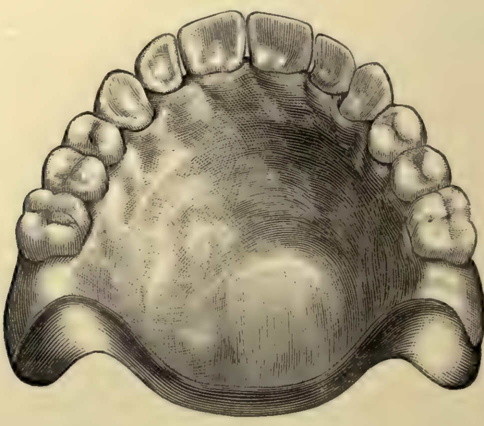
The lines and shoulders of junctions of the gums with the teeth should be carved with the utmost nicety. The flow of the paste is facilitated by dipping the spatula-blade in water.

The enamel over the lingual surface of the piece is to be thinner than over its buccal and labial walls. No special attempt is made in clearly outlining the rugæ in the enamelling paste, as the enamel in fusing distributes itself in nearly an even layer in the depressions between the rugæ: however the paste should be applied in a very thin layer between the crests; the rugæ receiving a greater depth of coating.

The case is to be dried *very* slowly at the mouth of the muffle, which should be dark. The slab holding the denture is then passed to the rear of the muffle and the full draft applied. When the full heat is attained the case is examined for any defects caused by the detachment of portions of the enamelling. Should any be found, the muffle-door is closed for a minute or two to effect the biscuiting of the enamel. The case is removed and placed in the cooling muffle for thirty minutes. The deficiencies or defects are remedied by the addition of enamel paste. A fresh fire is now required to properly fuse the enamel.

Should the enamel upon examination be found to be flawless, the muffle-door is to remain closed for from eight to ten minutes, when the enamel glazes. It is transferred to the cooling muffle, where it is to remain until cold. If upon a second examination any defects are found, these are to be remedied and the piece again heated as before.

FIG. 544.



The completed case.

When cool the denture is ready for finishing.

The rim is made smooth by means of fine files: all file-marks are removed by means of Arkansas stone, and the final finish given with burnishers and soap. The palatal surface of the plate is cleansed with powdered pumice, the interior of the chamber being burnished.

Repairing Continuous-gum Dentures.

The repairing of continuous-gum dentures, while undoubtedly a more tedious and lengthy operation than the repairing of other classes of artificial dentures, is not the serious drawback to its employment that some have stated. They may be readily repaired, and at the completion of the operation the cases are as strong as when new, and exhibit no indication of repair.

When cases present for repair they have, as a rule, been worn for some time after having been broken. Each piece may exhibit cracks, irregularities, and possibly, if the fracture be deep, minute spaces may exist between portions of the platinum plate and the porcelain. Into these spaces the secretions of the mouth and more or less food débris in a state of minute subdivision gain access. These must be entirely removed before any attempt is made at fusing new porcelain, for if this precaution is not taken the vapors generated in heating may expand with explosive violence and detach portions of the porcelain.

The case is encased in an investment of asbestos and plaster about half an inch thick. When hard, the investment containing the denture is placed over a gas-stove and dried ; the heat is raised gradually to redness, which carbonizes the foreign materials. The piece should cool gradually, and then be washed in castile soap and water.

The fire is prepared in the furnace ; the case is placed on the fire-clay slab, introduced into the muffle while it is still dark, gradually advancing the piece until it is as hot as the muffle, when the draft is applied and the case heated to redness, effectually decomposing all foreign materials which may be present in or about the denture. Removed to the cooling muffle, it is to remain for about half an hour.

If the repair is to be of a tooth or teeth, the porcelain and any remnants of the original tooth or teeth are to be ground away to the depth and curve of the cervical outline of the teeth. At the lingual portion the porcelain is ground away until the original platinum stay is exposed.

Teeth are selected of the mould and shade of those on the denture, and are ground to fit accurately the spaces made for their reception, and waxed in position. A coating of shellac is applied to the new teeth, and the case is invested, carrying the investment over the tips of the teeth so that they will be held in position. A stay is fitted under the pins, its base joining the old stay ; the pins are bent down and pure gold is applied for soldering. This soldering is to be done in the furnace : the unequal heating involved in soldering under the blowpipe might endanger the integrity of the piece. The case is introduced into the muffle, and as soon as the solder flows, uniting the tooth to the stay and the latter to the old stay, the piece is removed to the cooling muffle, where it remains until the denture itself is scarcely warm. The investment is removed, and the case washed with soap and water.

It is rarely necessary to apply more than one coating of body for repaired cases. The body is applied as before, heated to the granular stage ; a second heating vitrifies the enamel applied as a second coating.

Should a case be damaged beyond simple repair, or found to be so full of defects as to be unfit for use, the ceramic part of the work may be done anew without the taking of a new impression and articula-

tion. The palatal surface of the plate is oiled and a plaster cast run in it. When this is hard it is mounted in an articulator set to the proper distance: the tips of the teeth are to be imbedded in soft plaster placed over the second arch of the articulator. The denture is heated to redness in the furnace and plunged into cold water. This heating and chilling are repeated until the porcelain, teeth included, may be readily detached, leaving the platinum plate uninjured and the stays in position. A new set of teeth is fitted to position, the stays and the articulating model furnishing the guides for their adaptation. These are soldered as the original teeth, the porcelain attached as described.

Single Teeth attached in Blocks by Means of Continuous Gum.

Cases are occasionally seen in which the plain teeth as procured from the manufacturer are of the correct sizes, forms, and colors, and yet in order to effect a harmonious restoration of gum contour gum blocks or single gum teeth made in the stock moulds are inapplicable. It is possible in such cases that the correct gum form may be had by the process of continuous-gum baking. An impression is taken, and a model made representing accurately the space to which the teeth and artificial gum are to be applied. The outline of the future gum is to be marked on the model, and a line made inside the cervical outlines to be occupied by the artificial teeth upon the palatal aspect of the model. Dies and counter-dies are made, and a plate of No. 29 platinum swaged to fit the model and correspond with the marked lines. An articulating model is made; plain teeth are selected—plate teeth if the future plate is to be of gold or silver; rubber teeth if it is to be of vulcanite. The teeth are arranged and articulated. They are cemented to the plate and invested in asbestos or plaster. A stay is fitted to each tooth, and the parts united as for continuous gum-work, with 24-karat gold as solder. The plate returned to the model, the body and enamel are successively moulded to the plate as for continuous-gum work. The stays and palatal aspect of the platinum are to be entirely free of the porcelain, as these surfaces are to be soldered to the body of the future plate.

The edge of the platinum plate is bevelled and its line marked on the plaster model. A film of wax is applied over this line, so that the die will be raised sufficiently to have the plate, when adapted to the die, overlie the edge of the platinum.

Dentures of Continuous Gum Mounted on Vulcanite Plates.

It was stated early in this chapter that the form of vault known as the high or peaked is that in which dentures of continuous gum afford the least satisfactory results.

The lightness and accuracy of adaptation to be had with plates of vulcanite may be combined with the æsthetic features recommending continuous gum. The model is prepared for swaging the type of rim fitted for a continuous-gum denture. A plate is swaged to fit the alveolar walls and form a rim; the plate is to extend for about a half inch over the palatal portion of the alveolar wall. Along this portion

of the plate edge platinum wire No. 19 is to be fitted and soldered. The platinum plate is placed on the model, a trial plate completed by means of a wax base-plate, and an articulation is taken. Plain teeth of the variety designed for rubber work are to be fitted; stays are adapted to the teeth and plate.

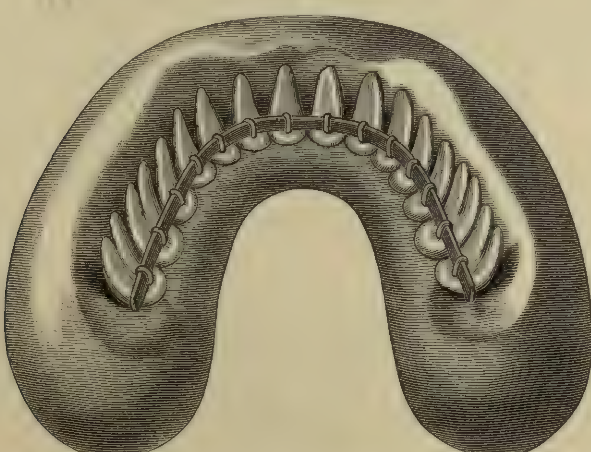
The porcelain is attached to the labial and buccal surfaces as with a continuous-gum piece. The palatal portions of the plate, the stays and heads of the pins, are left uncovered.

The piece is now adjusted to the model, the base-plate formed of wax. The investment in the flask is made as for rubber work; the platinum plate and teeth are to occupy the lower section of the flask. In finishing the plate the vulcanite is cut on the palatal surface to show a sharp line of demarkation at the line of junction with the platinum plate. This method is especially applicable for full lower cases where it is probable that extensive cutting will be necessary to properly adapt the plate to the mouth.

Another method of forming a continuous porcelain gum above plain teeth is occasionally practised, which does not involve the making of a platinum base-plate. It is less accurate than the latter method, but involves less labor.

Upon a trial-plate of wax, teeth designed for continuous-gum work are arranged. The appropriate fulness and contour are given the gum portions of the wax. The wax is chilled and the palatal portion of the plate cut away, leaving the arch of wax holding the teeth in position.

Fig. 545.



The denture and wax are removed from the model. The teeth are to receive a preliminary coating of plaster of Paris, painted on with a camel's-hair pencil.

The piece is now invested, the crowns of the teeth downward, in a mixture consisting of equal parts of fine silex, asbestos, and plaster. A horseshoe-shaped bed of the investing material, about half an inch thick, is placed on a glass slab, in which the occlusal surfaces of the teeth are placed. The investment is built about the wax gum, covering it to a

30

depth of half an inch and extending well over its edge. When the investment is hard, it is cut away sufficiently to permit of its easy introduction into the furnace muffle. Boiling (not merely hot) water is poured into the investment, washing away every vestige of wax. The piece is now warmed until perfectly dry: for this purpose it is placed in the muffle. When cooled sufficiently to handle a piece of half-round iridio-platinum wire No. 19 is fitted around the arch, resting upon each tooth above the pins. The wire held firmly in position, each pin is to be bent over it so that it is immovable (Fig. 545).

The walls of the mould being oiled, a mixture of body in water is made and thoroughly packed against the wall left vacant by the removal of the wax. The mixture is to be well packed in front of the roots; the body is made flush with the lingual edges of the teeth at the sides of the roots; its upper edge is to be made thin and bevelled. Small pieces of pure gold are placed at the lines of junction of the pins and wire, and the case is introduced into the furnace muffle. When it is ascertained that the gold has melted, attaching each pin to the wire, the muffle door is closed until the body is fused to the granular stage. When the investment has been in the cooling muffle for about fifteen minutes, it is plunged into boiling water, which soon disintegrates it. Any particles of investing material found adhering to the body are ground away.

Fig. 546.

Lower set of continuous gum set in vulcanite.

Any defects or deficiencies are remedied by further applications of the body mixture, and this additional coating is to be fused to the same extent as the first. The enamel is next applied and fused.

Any grinding necessary to permit the correct adaptation of the block to the model is done. The subsequent operations are those of vulcanite work. This method, as stated, is less accurate than that of the porcelain attachment to a platinum arch.

In making continuous-gum pieces to be mounted upon full lower plates of vulcanite the model is to have a plate of gutta-percha moulded over it: this is varnished. Dies are made, upon which a plate of No. 32 platinum is constructed. This plate set over the gutta-percha, teeth are arranged upon it and a continuous-gum attachment formed. The platinum plate is roughened and a vulcanite base made (Fig. 546).

FORMULAS FOR MAKING BODY AND GUM ENAMEL FOR CONTINUOUS-GUM WORK.

THE following formulas are the result of a series of experiments made with a view of producing a porcelain body which will fuse at a lower temperature than the majority of bodies and enamels commonly

used in the continuous-gum method, possessing at the same time strength, firmness of texture, and freedom from liability to crack or check on cooling. It is believed that if the proportions herein given and the rules for their preparation are strictly adhered to, a porcelain will result which may be relied upon to thoroughly fulfil the requirement of continuous-gum materials.

The body is composed of feldspar, glass or flux,[1] and kaolin, colored with titanium. The gum enamel is composed of feldspar, flux, and gum frit.

The composition and preparation are as follows :

Body.—Take of finely-powdered feldspar, 40 pennyweights ; flux, 9 pennyweights ; kaolin, 3 pennyweights. These are to be mixed and ground dry for half an hour, and placed on a fire-clay slide previously coated with finely-ground silica, and burned in a muffle to a state of vitrification, and when cool broken up and ground until it all passes through a No. 10 bolting-cloth sieve.

Gum Enamel for Continuous-gum Work.

Flux	12 pennyweights.
Feldspar	40 "
Gum frit[2]	2 "

Grind for one hour and fuse thoroughly on a fire-clay slide in the muffle of the furnace. When cold break into small pieces and grind until the powder passes through a No. 10 bolting-cloth sieve, after which 6 grains of gum frit are to be added to each ounce of the enamel powder and mixed with a spatula.

Before burning the material upon the fire-clay slide the latter should always be coated with fine silex to prevent the enamel from adhering to the fire-clay.

[1] See directions in chapter on Porcelain, page 223, for the preparation of flux, sometimes called dental glass.

[2] The formula and directions for the preparation of gum frit will be found on page 221, chapter on Porcelain Teeth, etc.

CHAPTER XIV.

CAST DENTURES OF ALUMINUM AND FUSIBLE ALLOYS.

BY C. L. GODDARD, A. M., D. D. S.

CAST-METAL DENTURES.

THE principle of casting metal dentures has long been recognized as the most desirable for obtaining accurate adaptation. In order to obtain the best results the following are essential: A metal or alloy which has (*a*) sufficient strength; (*b*) which will not deteriorate in the mouth; (*c*) which will have no deleterious action on the teeth or mucous membrane; (*d*) which is light, or, in other words, has a low specific gravity; (*e*) which in casting will take a sharp impression, or, in other words, follow the fine lines of the mould; (*f*) which will not discolor in the mouth; (*g*) which can be readily attached to the teeth; (*h*) which has a reasonably low fusing-point; (*i*) and can be cast in an easily constructed mould.

Tin is the chief component of alloys for this purpose. Other metals are added to lower its specific gravity, control shrinkage, and produce a sharper casting. These are silver, bismuth, gold, and in some instances cadmium and antimony.

Several of these alloys, such as Wood's, Watt's, Weston's, and Moffatt's, are proprietary; hence their composition is not known to the profession.

Most of these alloys are too heavy for superior dentures, but that objection may be remedied to a great degree by casting a plate only and attaching the teeth with vulcanite.

The following formulas have been given to the profession:

Kingsley's alloy, tin, 16 ounces; bismuth, 1 ounce.

Reese's alloy, tin, 20 parts; gold, 1 part; silver, 2 parts.

Bean's alloy, tin, 95 parts; silver, 5 parts.

(For aluminum alloys, see page 147.)

Cast and Investment.—As the use of all these alloys depends on making the cast and investment of a material which will not crack nor change shape in drying, one description will answer for all.

The impression is taken, as usual, with plaster, wax, or modelling compound, according to individual preference. If a vacuum chamber is desired, it is best to carve it in the impression, so that the pattern will be represented in the cast, or the central portion may be slightly scraped so as to make an undefined chamber over the hard parts.

The cast is made of equal parts of plaster and sand, asbestos, marble dust, chalk, or whiting. The latter is best, as it gives the smoothest casting. The same material is used for investing. A vacuum chamber pattern may be made on the cast, as thus described by Dr. Chupein:[1] "A piece of base-plate wax is softened and neatly moulded over the entire

[1] *American System of Dentistry*, vol. ii. p. 683.

face of the model. The paper pattern of the vacuum chamber is laid on the wax in the position it is to occupy and the form is traced on it. The pattern is then lifted off, and this part of the wax is cut out with a warmed wax-knife, leaving the model exposed. The exposed part of the model is then roughened and well moistened with water, and plaster of Paris and pumice-stone (or whiting), mixed in the same proportions as for the model, are incorporated with water and poured into the space made by cutting away the base-plate as has been described. When this has set so as to be quite hard, the wax base-plate is softened and lifted from the cast. The vacuum chamber model is then scraped down to the proper thickness."

The central part of the lingual surface of the cast may be raised by adding with a camel's-hair brush a thin mixture of plaster, whiting, and water, and thus a pattern made for an "undefined chamber."

For a base-plate use sheet wax, wax, and paraffin or modelling compound, rolled to one-twentieth or one-twenty-fourth of an inch in thickness. This is easily done by means of a smooth board and a roller or section of a broomstick. Wet both board and roller. Warm a sheet of wax and roll it out quickly.

Beads.—The cast plate is the only metal plate upon which a bead may be formed on the palatine surface. Such a bead, condemned by many, has been, in the writer's experience, very valuable in cases in which the mucous membrane was very soft. Such a bead, made around either a defined or an undefined chamber or around the plate about one-sixteenth of an inch from the palatine, buccal and labial borders, imbeds itself in the soft tissues and acts as a valve to keep the air from under the plate. The writer recalls one partial case in which the plate fitted perfectly, but would stay in place but a few minutes, the patient being conscious of the air entering under it. A cast was made in this plate, and a new plate made which differed from the first only in a bead which surrounded the chamber at the distance of about one-eighth of an inch. The second plate was a complete success.

To make such a bead use a small scoop excavator, and make a round-bottomed groove in the cast wherever the bead is needed. Sometimes the device is of advantage across the plate about an eighth of an inch from the posterior border. (See chapter on Vulcanite.)

The thin wax base-plate is more easily adapted to the cast if both are immersed in warm water and the wax moulded on the cast with thumbs and fingers. By then immersing in cold water the wax is made rigid.

On this base-plate the teeth are mounted as in rubber work, and the plate contoured according to the needs of the case. The smallest possible quantity of wax should be used, as it is to be remembered that the metal alloy which takes its place is much heavier than vulcanite.

Fig. 547.

Teeth for vulcanite work are best adapted for this work, but if the pins are very prominent they should be bent nearer the necks of the teeth to avoid excess of metal plate.

In partial cases of close bite a tooth may be backed with gold or silver and the backing extended half an inch or more into the wax-plate (Fig. 547). This projecting portion should be roughened or have holes punched in it for better retention in the alloy.

If gum teeth or blocks are used, grind off the thin upper portion of the gum at right angles or at a slightly obtuse angle with the labial surface. This is to prevent fracture by contraction of the metal when cooling.

As the thin wax advised for a base-plate is readily bent out of shape, it is better to use a more rigid base-plate, preferably of modelling compound, for taking the bite and mounting the teeth. After trying in the mouth and making any necessary change in position of the teeth, put the case on the cast, and stick it there securely by melting the wax around the upper border of the plate with a hot spatula, adding sticky wax temporarily in convenient places. With a hot spatula cut out the thick base-plate from the lingual portion and substitute a layer of thin wax about No. 23 B. & S. G., or two or three layers of the thin wax sheets used in making artificial flowers. Smooth the wax around the necks of the teeth ready for flasking.

FIG. 548.

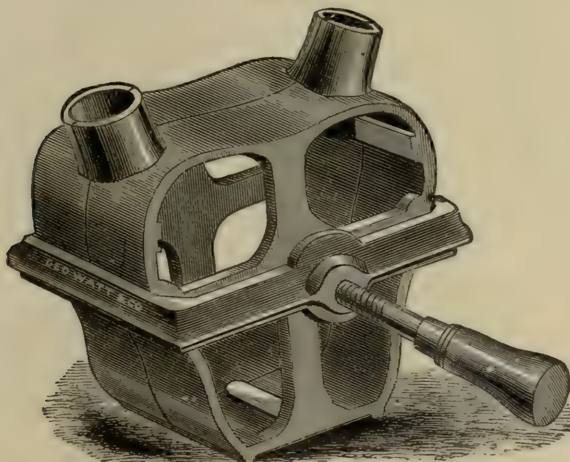
Weston's improved flask.

In some cases in which the necks of the teeth rest on the cast it is best to imbed the case in the lower half of the flask before substituting thin wax for the lingual portion.

After the wax is made as smooth as possible it may be given a gloss with slight puffs of the blowpipe flame. Figs. 548 and 549 show flasks used for this work.

The object of the length is to give room for a long gate, so that a column of the metal as it is poured in will force the lower portion into

Fig. 549.



Watt's moulding-flask.

all the intricate parts of the mould. For this reason the case should occupy the lower end of the flask. Lay the lower half of the flask on a smooth surface, such as glass or wood covered with paper or waste rubber dam. The latter is best, as it separates easily from the plaster. Invest as for vulcanite work, but with the same material used in making the cast. Trim the investing material so that the mould will "part" at the upper border of the wax base-plate.

Cut pouring and vent gates half the desired depth. These will differ according to the flask used. Use a small vulcanite scraper. With the Weston flask begin at the pouring gate at the upper end of the flask, and cut the gate of the same size, but decrease it gradually for about half the distance to the mould; then for an upper denture broaden the gate till at the posterior border of the mould it is about an inch wide and not much deeper than the thickness of the wax base-plate.

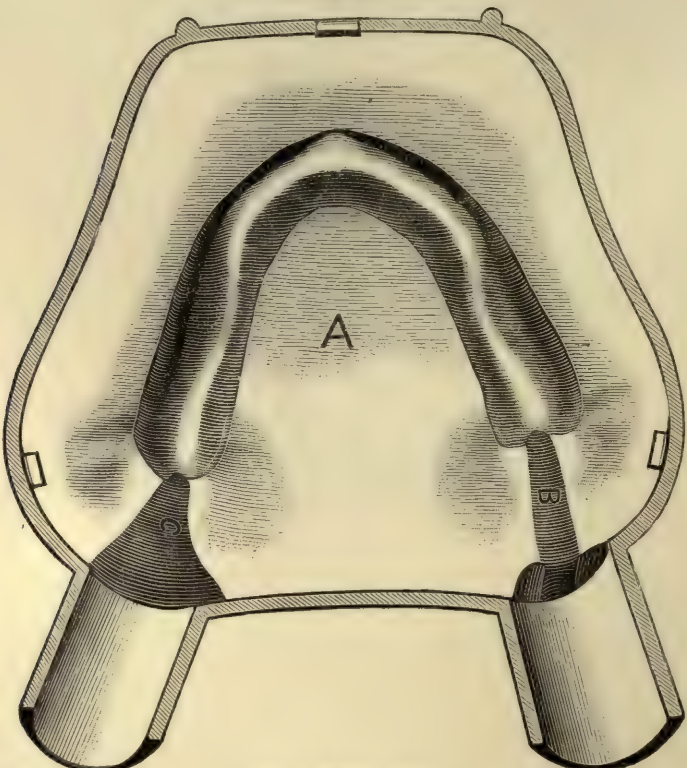
For a lower denture extend the gate about three-sixteenths of an inch wide till it reaches the mould in the region of the incisors. Cut two other gates in each side from the main-gateway, one to each end of the mould and one to the region of the bicuspids.

When the Watt flask is used (Fig. 550) two gates are cut, one from each "heel" of the plate to the funnel opening above it; one of these is made small all the way, and the other, small at the beginning, should increase in size till at the top it equals that of the funnel.

Coat the investing material in the lower half of the flask with a thin mixture of whiting or chalk and water; varnish it with thin shellac varnish or rub it with pulverized soapstone. The object is to fill up the pores and prevent adhesion of the investing material. Add the second

half of the flask and fill carefully with investing material, tapping the rim slightly to make any air-bubbles which may be present rise to the surface. Smooth the upper surface before it hardens.

FIG. 550.



Gates in Watt's flask.

When the investing material is hard, warm the flask slightly, part it, and remove the wax. From a small tea-kettle pour a stream of boiling water in the mould to wash out any wax remaining around the pins or in places difficult of access. The position of the gates cut in the lower half of the investment will be shown by ridges in the upper half. By marking a slight cut at each side of the ridge and making a groove in place of the ridge the gates of the two halves will correspond.

Fasten together the two halves of the flask and lute the joint carefully with investing material to prevent escape of the metal. Dry the flask over low heat an hour or more till all moisture is driven out. The presence of moisture may be determined by holding a mirror over the gate. If the mould is perfectly dry, no steam will be condensed on the glass. Do not apply heat too rapidly or steam will form in the mould and crack it.

Melt the metal in a clean iron ladle or in a crucible, being careful not to overheat it, and pour it in the mould while the mould is still hot. If poured in a cold mould, the metal does not take so sharp an impression,

being chilled and solidified before it reaches the finer parts of the impression. The nearer the temperature of the mould is to the melting-point of the alloy the finer will be the cast. If the joint of the flask is well luted, no metal will escape.

After the flask is cold it may be opened, the denture removed, and the surplus parts sawed off. These may be laid aside for future use, as remelting will not injure the alloy unless the temperature has been carried too high and some of the component parts oxidized, changing the formula of the alloy.

The denture should now be smoothed with files and sand-paper, then polished with pumice-stone, and finally with chalk or rouge. This will require less time in proportion to the pains taken in smoothing the wax.

Enough metal should be used to fill the mould and the gates full, so that the weight of metal at the top will force the lower portion into all intricate parts. If the mould is not full, keep it hot till more metal can be melted and poured in.

If, after the mould is opened, it is found that it has not been filled thoroughly, it should be closed, fastened, and the joint luted, then heated to the melting-point of the alloy. Pour in more metal and tap the mould gently with a small hammer to dislodge any air-bubbles present and settle the metal in the finer parts.

Repairs.—A tooth may be added by cutting out a dovetailed space for the pins, waxing it in and investing in the flask in about the same manner that a vulcanite denture would be invested. That is, imbed the plate in the lower half of the flask and cover it, all but the wax portion. Place it in such a position that a channel can be cut from the wax to the pouring gate. Complete the flasking as usual, remove the wax, dry the whole, melt some of the metal, and pour it in.

Soldering.—Solders are provided by different manufacturers. Make a dovetailed space in the plate, fit and wax the tooth in place as usual, then imbed an investing material, leaving the wax exposed. Remove the wax, dry the case, apply dilute chloride of zinc to the metallic surface exposed, place a piece of solder in position, and apply the heated soldering-iron till it is melted. It may be necessary to press the solder into the space with a wad of paper. Wood's metal, melting at 180° F., may be used as a solder in such a case. Investment is not always necessary, as sometimes a tooth or block may be held in place with the fingers, protected by a wad of paper, while the solder is fused.

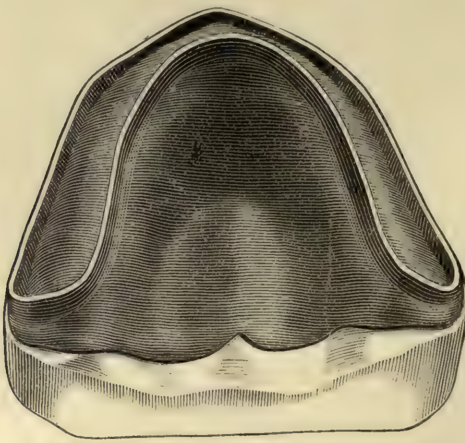
A tooth may be added or attached to a cast-metal plate with vulcanite by roughening the place of attachment, drilling holes in the plate in different directions, and countersinking them if they pass through the plate, or by cutting a dovetailed space. The plate is then flasked, and the process continued as in repairing a vulcanite plate.

Vulcanite Attachment.—To avoid weight in entire superior dentures, many partial, and some inferior dentures, it is better to cast the plate alone and attach the teeth with vulcanite. In such a case make a thin wax-plate of the exact size needed, invest it, and cast a plate as previously described.

Attachment of vulcanite may be made by drilling holes in the plate and countersinking them on the palatine surface. A better plan is given by Dr. Kingsley: In the wax-plate on the ridge set several small gimp

tacks, imbedding the head in the wax and letting the points project in different directions. When the case is invested and the wax removed, the tacks will remain in the investment, and should be pulled out. When the plate is cast the tacks will be represented by projections of the metal base, which may be bent in the form of loops.

FIG. 551.

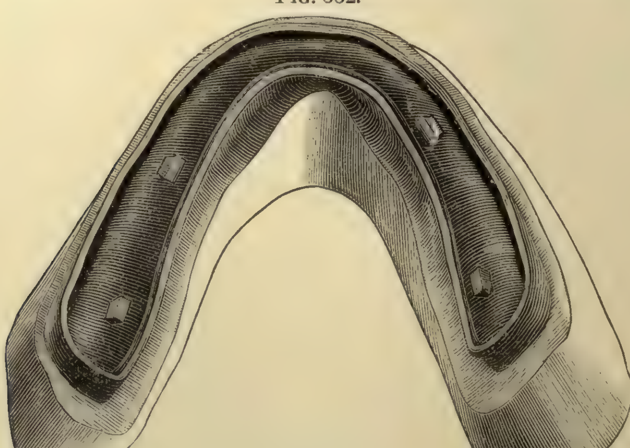


Upper cast plate for vulcanite attachment.

Another good plan, after the mould of a plain plate is made, is to make holes in the investment with a small drill wherever projections on the plate are needed.

A rim may be made on a plate by adding a wax rim to the wax-plate.

FIG. 552.



Lower cast plate for vulcanite attachment.

The rim and plate should be joined for at least one-sixteenth of an inch from the edge of the plate, then separated slightly. The first precaution is to allow trimming the border of the finished plate if necessary. Another band may be made on the lingual surface of the wax-plate with a

strip of wax. The line of union should be smoothed and the wax rim curved to conform to the general contour of the plate. On a lower plate the band should extend around both labial and lingual borders. These bands and rims will be reproduced in the cast metal as shown in Figs. 551 and 552.

The cast plate can be used for taking the bite and mounting the teeth in the same manner as a wax base-plate or a swaged plate for vulcanite attachment.

Clasps.—As these cast alloys are lacking in elasticity, clasps should be made of clasp gold and united to the plate in casting by providing suitable attachments, such as pins soldered to the clasp or extensions which may enter the plate a third or half an inch (Fig. 553). Where a standard clasp can be used the standard may be so bent as to extend into the plate. These clasps should be previously fitted in the mouth, then placed on the teeth of the cast and secured with investing material.

FIG. 553.

CASTING ALUMINUM.

On account of the low specific gravity and strength of aluminum many attempts have been made to make cast dentures of it, but the very quality which made it desirable in one respect was the cause of failures in casting. It is so light that it will not of its own weight run into a mould, at least not into an intricate one.

The first successful attempts at casting were made by Dr. J. B. Bean of Baltimore, who depended on the weight of a column of the metal several inches high to force the lower part into the mould. His flask was similar to those used for other cast dentures, but was provided with a detachable clay chimney which fitted accurately in the pouring gate. The flask and chimney were heated separately, then joined, and enough melted aluminum poured in to fill the mould and chimney. The weight of molten metal in the chimney was sufficient to force the mould full and make a very sharp and accurate casting.

Heretofore the chief obstacle to the use of dentures of aluminum has been its deterioration in the mouth. Aluminum of commerce was contaminated by iron or other metals which rendered it susceptible to chemical or electrical action, such action being often confined to small spots till perforations were made.

Aluminum Cast Dentures.—Dr. C. C. Carroll of Meadville, Pa., has invented a process of casting aluminum under pressure. To control shrinkage he has alloyed it slightly so that it can be cast directly on the teeth. He furnishes the following formula as the composition of his two bases:

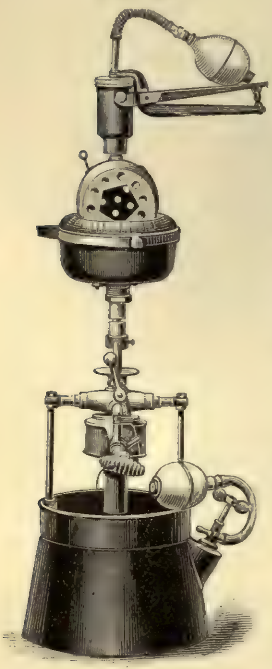
Base No. 1: Aluminum, 98 per cent.;
Platinum, Silver, Copper, } 2 "
Specific gravity, 2.5; fusing-point, 1300° F.

This is for superior dentures and must be cast under pressure.

Base No. 2 is composed of aluminum, tin, copper, and silver; specific gravity, 7.5; fusing-point, 700° F. This is intended for lower dentures and is cast without pressure.

To cast under pressure he used a crucible open at the top and terminating in a nipple at the bottom. The opening in the nipple connected with the inner part of the crucible by a siphon-shaped passage in the sides, so that the molten metal could not run out by gravity. In the top of the crucible was fitted a plug from which a tube led to a rubber bulb. By pressure on the bulb the air forced the molten metal through the nipple at the bottom.

Fig. 554.



The flask, similar to Weston's (Fig. 548), had an opening in the upper end in which the nipple of the crucible fitted tightly. The mould and crucible were heated separately till the aluminum was melted and the flask was nearly red hot. The crucible was then placed on the flask so that the nipple fitted tightly. The stopper was inserted in the crucible, and the rubber bulb connected with it squeezed so as to force the aluminum in the mould.

While cast aluminum is not as tough as swaged aluminum, yet a plate, especially a partial one, may be made stronger, because the thickness may be varied according to the strain.

Aluminum plates may be cast directly on the teeth or plates may be made for vulcanite attachment (Fig. 551). The process of making the base-plate and flasking is exactly like that described for other cast-metal plates, except that the wax may be thicker if desired, on account of the light weight of aluminum.

Gates.—Three round channels are cut in the mould, one from the middle of the posterior border to the pouring gate, and one from each "heel" of the plate to the edge of the flask. One of these connects with a vent hole.

Carroll's improved flask (Fig. 554) has a projecting gate-funnel, screw cut on the outside. The improved crucible screws on this, so as to make a tight joint. The crucible cover is held in position by a clamp with a handle a few inches long.

After flasking and removing the wax "bolt the flask firmly together and coat the thread of flask with soapstone. Screw the retort firmly to the flask. Place a fine copper wire in the vent, then lute the seam of the flask and where retort joins the flask, also around the bolts, with investing material, to prevent the escape of air or metal in casting. Test with the rubber bulb and clamping lever. Soapstone sprinkled over a suspected leak will detect it.

"Withdraw the wire from the vent and test again to see that only the vent is open. Place the flask in the slot of the burner, turn on low

flame, and dry out thoroughly, as will be shown if no moisture appears on the surface of a mirror held over the retort.

"When the piece is dry place the flask on the bottom of the burner; put two ingots of aluminum base No. 1 in the retort; place the hood over it and turn on full flame, and with use of foot-bellows attached to air-tube of the burner proceed to melt the metal, which will usually require from six to ten minutes.

"When melted, remove the hood, turn off the gas, and clamp the retort cover in place with clamping-tongs, slipping the ring over handles; then, with the rubber bulb pressed gently but firmly, force the melted metal into the matrix until the metal is forced through the matrix to the vent." "Chill the metal with a piece of wet sponge tied to a stick as soon as it appears at the vent. Press three seconds to condense the metal under pressure in the matrix. With the handles of the clamping-tongs unscrew the retort from the flask as it stands in the burner, and with bulb blow out all excess of aluminum from the retort."

When the flask is cool open it, cut off surplus parts from the plate, trim the edges, smooth with sand-paper (fine), and polish with fine pumice-stone and chalk or rouge. As aluminum is much harder than the "fusible bases," much more care should be taken—smoothing the wax model-plate.

Clasps.—As aluminum has much more strength than the softer plate alloys, clasps may be cast about the teeth by making proper wax models. A better plan, however, is to make gold clasps and connect them to the plate as in other cast metal or vulcanite work. (See Fig. 553.)

For casting a plate directly on the teeth the same precautions should be taken as those described on p. 470. The teeth should be spaced so that a postal card will pass between them to prevent cracking from the slight shrinkage of the metal.

After investing and washing out the wax, "make a thin cream of equal parts of carbonate of magnesia and prepared chalk with water, and with a small camel's-hair pencil cover the alveolo-labial edge of the teeth with a thin coating of this cream to prevent the metal from flowing over this edge and possibly checking the teeth."

"If the gum section teeth are used, grind the feather edge slightly bevelled, leaving the labial edge of the gum highest, and mount, spacing slightly by placing heavy writing-paper between the joints. Before investing remove the paper and flow between the joints the magnesia and chalk cream. Then invest the same as for plain teeth. After washing out the wax flow a thin film of the above cream along the bevelled edge of the gum and proceed to cast as directed."

Lower Dentures.—Carroll's aluminum alloy for lower dentures is lighter and more rigid than the plate alloys not containing aluminum, but it will flow of its own weight into the mould. It may be used exactly like the other alloys, or may be used with the aluminum outfit as follows: After the teeth are arranged as desired "trim and wax up neatly, and as light as intended to be when finished for the mouth. Then invest the model and the teeth in perforated flask and proceed as directed for base No. 1 up to the point of making the cast. When the matrix is dry and ready to make the cast, place two ingots of base No. 2 in the retort with the larger opening. Turn on flame enough to melt the metal in eight

to ten minutes, which requires not over half the flame needed for base No. 1. Stop the opening with an old plugger to prevent the metal escaping as it melts. When all is melted withdraw the stopper and chill the metal when it appears at the vent.

"If there should be any point of leakage of the metal, it can be stopped at once by touching it with a wet cloth, and any escaped metal can be immediately remelted and poured into the matrix without producing any flaw or imperfection in the piece to be cast. Let the piece cool slowly, remove from the flask, and finish as directed for base No. 1. Never use the same retort for melting base No. 1 and base No. 2."

The aluminum furnace can be heated with either gas or gasoline.

CHAPTER XV.

VULCANIZED RUBBER AS A BASE FOR ARTIFICIAL DENTURES.

By Charles J. Essig, M. D., D. D. S., and Warrington W. Evans, M. D., D. D. S.

Caoutchouc (or India-rubber) is the thickened milky juice of several species of Ficus, Euphorbia, and other trees growing in tropical countries, and is essentially a mixture of several hydrocarbons isomeric or polymeric with turpentine oil. When pure it is nearly white, the dark color of commercial caoutchouc being due to the effects of smoke and other impurities. It is softened, but not dissolved, by boiling water: it is also insoluble in alcohol. It dissolves in pure ether, chloroform, rectified petroleum, mineral naphtha, bisulphide of carbon, benzole, and most of the oils, both fixed and volatile. Dissolved in oil of turpentine, it forms a viscid, adhesive mass which dries very imperfectly. Caoutchouc melts at a temperature of 250° F., but little above the boiling-point of water, but does not again resume its former elastic state. By destructive distillation it yields a large quantity of a thin, volatile, oily liquid, having a naphtha-like odor, called caoutchin, $C_{10}H_{16}$, which dissolves caoutchouc with facility.

The caoutchouc of commerce contains a small quantity of albumin, derived from the original milky liquid, this being really a solution of albumin holding in suspension about 30 per cent. of caoutchouc, which rises to the surface like cream when the juice is diluted with water and allowed to stand, becoming coherent and elastic when exposed to air. The specific gravity of caoutchouc is 0.93. The chief uses of this substance depend upon its physical rather than its chemical properties, its lightness and impermeability to water adapting it for the fabrication of many articles intended for the exclusion of moisture, while its remarkable elasticity gives rise to numerous other applications.

Vulcanizable caoutchouc is produced by incorporating sulphur with caoutchouc in proportions varying according to the uses for which it is intended, the hardness of the product being governed by the amount of the indurating agent present.

Hard rubber for dental purposes (ebonite) is produced by exaggerating the conditions of ordinary vulcanization or increasing the proportion of sulphur added, and lengthening the period during which it is allowed to react on the rubber. The sorts of rubber best suited for the production of ebonite are those hard and fibrous varieties which are procured in the islands of the Malayan Archipelago. To Dr. Thomas W. Evans of Paris, France, is undoubtedly due the credit of having made the first dental plate in hard rubber, and of having also first applied steam heat for the

vulcanization of caoutchouc in chemical combination with sulphur and other pigments as coloring matter, etc.: this was in 1844 and 1845; later on, between 1848 and 1850, Goodyear provided some fine specimens of ebonite work which demonstrated the industrial value of the material.

There is some difficulty in obtaining accurate formulas for compounding the rubber used in the manufacture of dental plates, as naturally the manufacturers, who are in mercantile competition with one another, are not willing to publish their recipes. The formulæ which seem to approximate the compounds are those given by Dr. E. Wildman, as follows:

Dark Brown.

Caoutchouc	48 parts.
Sulphur	24 "

Grayish White.

Caoutchouc	48 parts.
Sulphur	24 "
White Oxide of Zinc	96 "

Red.

Caoutchouc	48 parts.
Sulphur	24 "
Vermilion	36 "

Black.

Caoutchouc	48 parts.
Sulphur	24 "
Ivory-black or deep-black	22 "

Dark Pink.

Caoutchouc	48 parts.
Sulphur	24 "
White Oxide of Zinc	30 "
Vermilion	10 "

Jet Black.

Caoutchouc	48 parts.
Sulphur	24 "
Ivory-black or Drop-black	48 "

RUBBER DENTURES.

It is important that the model used in the construction of a rubber denture should be formed of the hardest variety of plaster, so as to enable it to sustain without danger of fracture the great pressure to which it is subjected after packing, and while the two parts of the flask are being forced together. It should also be regarded as imperative in rubber work that the surface of the model be absolutely free from minute air-bubbles or other imperfections incident to hasty or careless mixing of the plaster, improper preparation of the surface of the impression, etc., as all defects of the surface of the plaster model will be found clearly defined in the rubber plate when finished, and the minute points or prominences so formed act as irritants to the delicate tissues upon which they rest.

A slow-setting, coarsely-ground plaster of great hardness can always be obtained at the establishments where plaster ornaments for building purposes are manufactured, and is much better suited, both for the formation of the model and for flasking the denture, than the grades of plaster usually supplied by the dental dépôts.

Every detail of laboratory work should be done intelligently and with care, even in the mixing of plaster—a process which many consider unimportant. The result may be greatly impaired, although the material used be of the most satisfactory quality, by mixing with too large an amount of water, and neglecting to exclude the air before stirring the plaster, by not dropping it into the water and allowing it to settle, as described in chapter on Models.

The model should be trimmed to a size and form corresponding with the dimensions of the flask. The next step is to arrange the vacuum chamber, which is usually formed of a piece of "chamber metal" consisting of lead with a coating of tin on both sides. This combination is

admirably adapted for the purpose on account of its flexibilty: tin alone would require so much force to bring it into close contact with the model that damage to the latter might result, while, on the other hand, lead alone, while possessing softness enough to enable it to readily take the form of the palatal portion of the mouth without much pressure, combines to some extent with the sulphur of the rubber, and thus prevents perfect vulcanization at the point of contact. The shape and size of the chamber should conform to the outline and dimensions of the model; its position should be posterior to the rugæ, and it should not be allowed to include to any considerable extent the sloping sides of the ridge. (See chapter on Models.)

The chamber may be carved in the impression, and some operators prefer this method. It has the advantage of being fixed, and therefore free of the danger of becoming accidentally moved out of its correct position when the two parts of the flask are brought together.

There are cases occasionally met with where stronger and better atmospheric adhesion can be secured without the vacuum chamber. In such instances the whole plate may be given somewhat the character of a vacuum chamber by cutting with a broad Palmer excavator a half-round groove entirely around the plaster model a little above the line which marks the extent of the plate. The groove will be represented on the vulcanite denture by a raised line of about the thirty-second of an inch in width and somewhat less in thickness. This raised line very soon becomes imbedded in the tissues and prevents the ingress of air, but care must be exercised in finishing the piece to avoid filing away any part of it, otherwise it ceases to be of service.

The Base-plate.—There are numerous materials used in the formation of the temporary base-plates for rubber and celluloid work upon which the wax articulation is taken. In the early days of rubber work the temporary base-plate was invariably made of sheet gutta-percha softened by dipping it in hot water and pressed to the plaster model with the thumb and fingers, and then trimmed to the desired dimensions: it was, however, objectionable on account of its yielding character, the consequent uncertainty as to the correctness of the bite, and the liability to impair the condition of the surface of the plaster model while making it. All forms of sheet wax, paraffin and wax, etc. are unreliable as materials for the formation of articulating plates, for at least one of reasons urged against the use of gutta-percha—extreme pliability.

The most reliable of the materials for forming temporary or articulating base-plates, and one that may be made without great expenditure of time, is the tinned lead used for making chambers. This metal can be obtained of any desired thickness, and by making one zinc die and one lead counter-die a close-fitting and sufficiently rigid plate may be prepared which will not be likely to yield when the bite is taken in the mouth. When the metallic base-plate is used, it should be of the thickness of No. 21 of the standard gauge: this will require, in the final waxing up, the addition of a sheet of extra-thin wax warmed over a spirit lamp and pressed to close contact with the metal plate by the thumb. By this means the finished denture will have a uniform thickness of about No. 17 of the gauge. Another excellent method of preparing temporary base-plates is to take a sheet of stout pattern metal

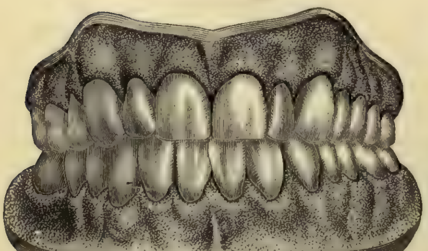
and press it to the model with a piece of erasing rubber; a sheet of wax is then warmed and pressed to the metal; and, finally, another layer of pattern tin is pressed to the wax: this affords a plate composed of two thicknesses of pattern tin with a sheet of wax between them. If the latter is of the extra-thin variety, the combination will afford a plate of the proper thickness, No. 17, and the plate will be found to be nearly as rigid as the one of chamber metal.

When sheet wax or paraffin and wax are used for a base-plate, the plate can be strengthened by a piece of iron or brass wire of not less thickness than No. 15 or No. 16 of the standard American gauge, bent to fit the ridge of the base-plate and securely waxed to it. This wire is indispensable in lower base-plates of wax.

Taking the Articulation.—This is an operation which admits of a much wider scope in rubber work in the restoration of the natural expression, which is always more or less changed by the loss of the natural organs, than was possible when the prosthetist was restricted to the gold or silver denture. Paraffin and wax is preferable for articulations on account of the proximity of color to the natural teeth, an ordinary cake of the material softened over the flame of a spirit-lamp, and doubled and rolled upon itself until it assumes a cylindrical shape of sufficient length to occupy the greater part of the alveolar ridge, and to receive impressions of all the antagonizing natural teeth, if any remain. While still quite plastic it is moulded with the thumb and fingers to near the height and fulness required by the particular case, after which considerable time may be spent in trimming the wax away at some points and making additions to others until a quite natural expression of the mouth has been obtained.

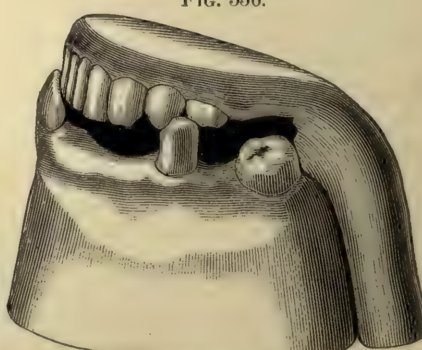
This part of the construction of an artificial denture is purely artistic, and there is but scant basis for the formulation of rules which shall guide the student with any degree of certainty in the restoration of the correct facial expression. With exactly the same materials two operators will

FIG. 555.



Showing plumpers for restoring expression.

FIG. 556.

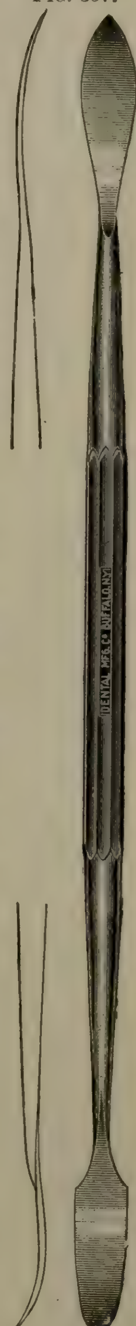


Antagonizing model, partial upper denture.

obtain widely different results: the denture prepared by one will blend so harmoniously with the face as to become, as it should be, an inconspicuous feature, suggestive of nothing artificial, while the other will be entirely incongruous in effect.

There are four important points in the arrangement of the articulating wax which demand particular attention. These are, first, the correct length; second, proper fulness; third, the right curve; fourth, the filling up of depressions in the lips or cheeks incident to the loss of the natural teeth. A defect in either of these directions will be sure to impart to the mouth an unnatural appearance. The articulating wax should be recognized as a reliable guide for the subsequent fitting and arranging of the porcelain teeth, and, having been completed in a satisfactory manner, it should be closely followed.

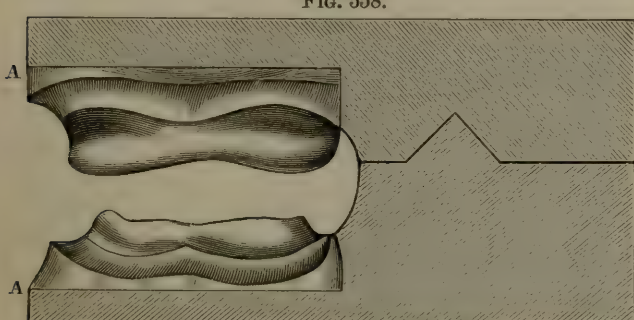
Fig. 557.



The statement is often made that with the loss of the cuspid teeth permanent changes occur in the facial expression which cannot be entirely restored; but the author has found that in rubber dentures the depression caused by the loss of the teeth, as well as the changes which occur in the cheeks from similar causes, may be entirely restored by properly arranged prominences of the rubber rim, as shown in Fig. 555.

The articulating or antagonizing model should be made upon the cast, as shown by Fig. 555. The cut exhibits the arrangement for obtaining the bite of a partial denture, but, as the idea is precisely the same in entire upper or lower dentures, it will answer to illustrate the relation of the antagonizing model to the cast. In making the antagonizing model for an entire rubber denture the upper and lower waxes are to be temporarily united in their correct relation to each other by hot wax applied at two or three points by means of a spatula (Fig. 557); they are detached from their respective models, and the latter are cut down to the dimensions required for their reception in the vulcanite flask. They are then each given a partial coat of sandarac varnish on their base

Fig. 558.



sides to prevent too great adhesion to the plaster articulator and to ensure their safe separation from it when the fitting and arranging of the teeth are finished: to accomplish the separation it is only necessary to introduce a knife-blade at the

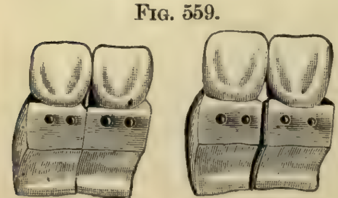
points indicated by *A*, *A*, Fig. 558, and pry them gently apart. Plaster antagonizing models are more convenient to handle than are any of the metallic articulators supplied by the dental dépôts. Being in two unattached parts, one section may be laid aside, instead of dangling by a hinge, while the teeth are being tried in place. The articulation, properly so called, is taken in the mouth, the mouth being the true articulator. The antagonizing model merely fixes the correct relation of the lower to the upper ridge. It is stated that the function of the metallic articulator is to enable the workman to change the bite by either shortening or lengthening if he deems such modification desirable. A change in the articulator nearly always impairs the accuracy of the relation of the dentures, because with the exception of the instruments of Bonwill and of Walker the forms of these mechanical fixtures are not anatomically correct, and therefore, while they may be employed merely to fix the relation of the inferior to the superior teeth, they cannot be relied upon as a means of changing the bite.

Teeth used in rubber work are especially designed for that purpose, and are made in the form of sectional blocks, single gum, and plain teeth. Objections to the use of the former consist in the difficulty frequently met with in adapting them to the curve of the alveolar ridge and in their limited range in the imitation of irregularities. On the other hand, the gums of sectional rubber block teeth may be made to imitate nature more closely than is possible with any of the colored rubbers now in use for the purpose. Single gum teeth for rubber work are practically obsolete for the construction of entire dentures, on account of the number of joints necessary in fitting them together, the liability of the latter to become discolored by the rubber, the labor of fitting them together, and the difficulty of imitating irregularities of position.

The most artistic effects are obtained with plain teeth : they are much easier to manipulate, less liable to the danger of breakage in packing, and during subsequent operations, and are almost entirely free from the vexatious shrinkage of the rubber from around the teeth so often observed in sectional blocks.

By the use of single plain teeth the operator has abundant opportunity for the imitation of the irregularities observed in natural dentures, and time and labor are saved through the facility with which they may be made to conform to the alveolar ridge. Fig. 560 to represent some excellent samples of plain rubber teeth that will be found available in a majority of cases.

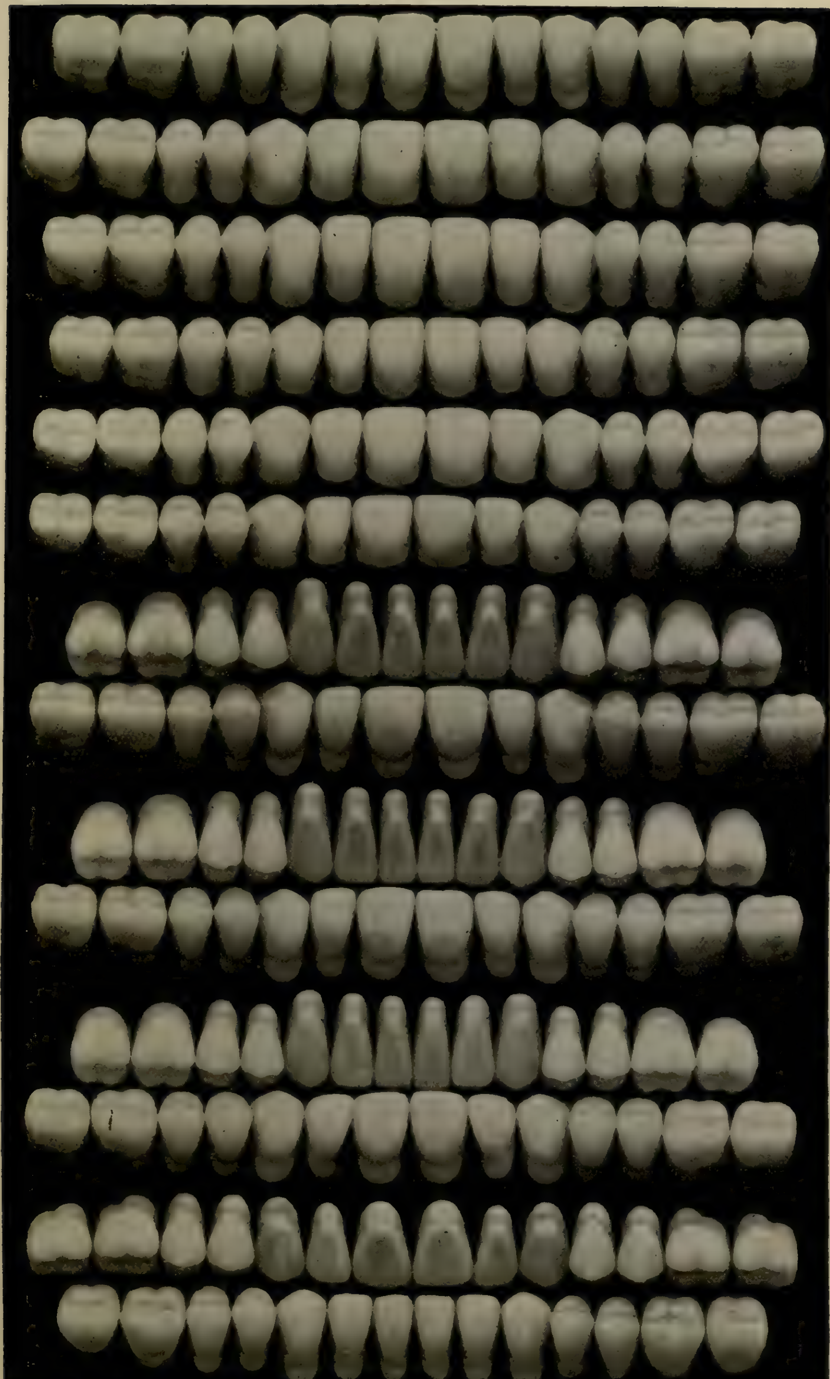
FIG. 559.



Correct way. Incorrect way.

If the gums are formed of pink rubber, and modelled so as to give the proper fulness to the lip and to imitate the irregularities of surface of the natural gums, the effect will not be bad. It is always better to keep the pink rubber, which is not a very close imitation in point of color to the natural gum-tissue, from being visible in laughing or talking. The artistic shaping of the gums, however, will greatly lessen the artificial appearance of the denture.

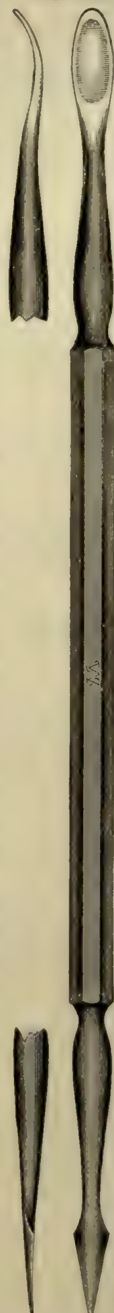
FIG. 560.



In the fitting of sectional blocks or single gum teeth—and the use of the latter is sometimes necessary in partial cases—certain precautions are requisite in the preliminary stages of the operation to prevent the joints from becoming discolored by the ingress of the rubber in packing.

Fig. 561.

Fig. 562.



Discoloration of the joints is due—First, to imperfect fitting of one gum section to the other; second, to want of cleanliness; third, to an over-abundance of rubber in the flask in packing; fourth, to an inferior quality of plaster, which is liable to yield when the flask is being forced together. In fitting sectional blocks or single gum teeth care should be taken in jointing the gums to have the surfaces that come in contact so ground that they will fit perfectly and not form a V-shaped space (Fig. 559); and in fastening the finished blocks or gum teeth to the plate not a particle of the wax or cement used for the purpose should be allowed to run into the joints, and when all the teeth are in position, and before the final "waxing up" is begun, fine plaster mixed with water should be forced into the joints, so as to fill the slightest crevice and effectually exclude the melted wax, which is somewhat freely applied with the spatula in giving the finishing touches to the waxing process. The plaster may be applied to the inside of the joints, and if mixed thin it will be drawn by capillary force entirely into any space, no matter how minute it may be.

Forming the Denture in Wax.—Having secured the teeth in position, wax is liberally dropped

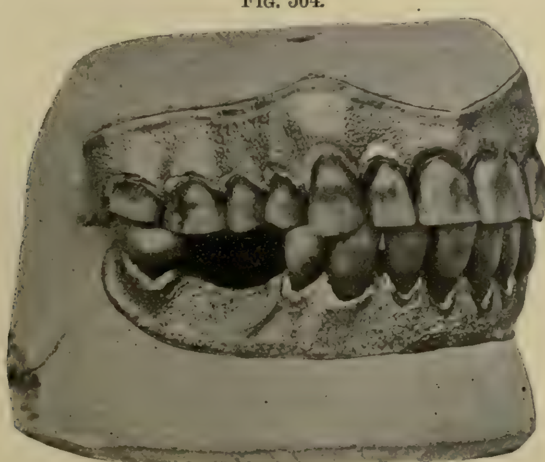
under them if gum teeth, and quite around them if plain teeth, being careful to avoid allowing any to drop on the palatal portion of the plate. When plain teeth are used, the wax is to be carved, as soon as sufficiently cool, around the necks inside and out with suitable tools: those shown in Figs. 561, 562, with accompanying burner (Fig. 563), will be found very convenient for the purpose.

The front should be carved to exactly represent the gums as they appear in nature and as the piece should be when finished. The plate, previously formed of wax or other suitable material, should be of a uniform thickness of about No. 17 of the standard American gauge, so that the rugæ and other irregularities of the palatal surface of the mouth may be observed. There is hardly room for doubt that the rugæ play an important part in mastication in assisting the tongue to change the bolus of food from one part of the mouth to another, and as aids in enunciation and deglutition. It seems, therefore, reasonable that a denture so arranged will feel less foreign to the patient than do those with perfectly flat surfaces wherein no attempt has been made to imitate the palatal configuration of the human mouth.

Fig. 563.

The waxed piece should be regarded as a pattern in wax from which a matrix is to be obtained for the purpose of forming the permanent rubber denture; and it should be remembered that the labor of finishing the vulcanized piece will depend upon the perfection to which the modelling of the wax pattern is carried. The operator will usually find that time and labor are saved by so shaping the wax pattern that little or no scraping, filing, or polishing is needed to

Fig. 564.



the vulcanized piece. When the carving of the wax is satisfactorily finished a few gentle puffs of a mouth blowpipe will flow the wax and produce a perfectly smooth surface when it is ready for the flask. A sheet of No. 60 tin-foil should be very carefully burnished over the wax

plate, both on the palatal portion and that part representing the gums. Fig. 564 shows a set with the gum portion entirely covered with tin-foil: the stippling observed on the surface is done by means of a blunt pointed instrument indenting the tin, care being taken to merely indent, but not puncture, the tin.

The foil should be cut to the proper dimensions and carefully brought in contact with the wax, at first with a piece of soft rubber, such as is used for erasing pencil-marks, to avoid folds, and then with the ivory or agate burnisher which accompanies the set of carvers (Fig. 561).

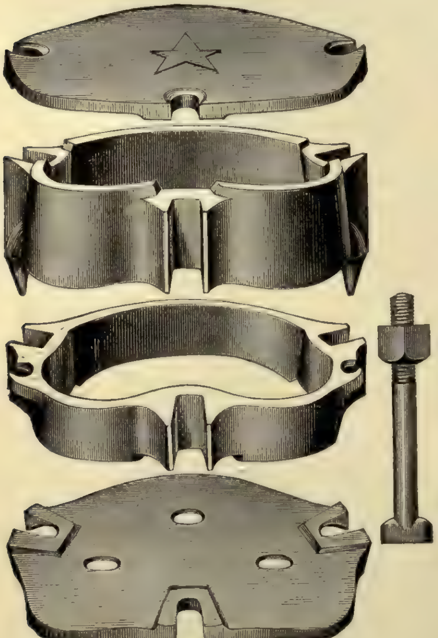
Care must, of course, be exercised in investing or packing the piece to avoid disturbing the tin-foil. The tin-foil on the palatal surface, if the operator prefer, may be put on after the denture has been invested in the lower section of the flask.

Flasks for the Vulcanizing Process.—There are many good flasks from which to select. They are usually made of iron or brass, and are divided into two sections with detachable top- and bottom-pieces, as shown in the illustration of the "Star reversible flask" (Fig. 565).

Fig. 566 shows the "Whitney slot flask." This flask has been extensively used for many years: it is not, however, reversible, and the bottom-piece not being removable, it has been to some extent superseded by the Star reversible flask on account of the greater convenience of the latter.

Figs. 567 to 572 show the different parts of the Griswold flask, an appliance of somewhat recent invention. Those who have used this flask report that it is convenient, strong, and capacious. It is made of three-thirty-seconds of an inch rolled brass of uniform thickness, the base and top being shaped by heavy pressure over steel dies, which leaves the flask polished inside and out. The uniformity of thickness, fineness of form, and flawless metal give it superiority over flasks of cast metal and ensures great strength and capacity, while at the same time it will enter the smallest vulcanizer. This flask is especially adapted to the "Griswold method," briefly described as follows: "Put the waxed-up

FIG. 565.



The improved Star reversible brass flask.

FIG. 566.

Whitney slot flask.

model in base *B* (Fig. 567), level the plaster to the gum and palate edge line as shown and varnish the surface. Lock the centre *C* (Fig. 568) on the base *B* by turning the coned nut *E, E* (Fig. 567). Soap-lather the varnished surface to the gum and palate edge line, pour and level the

Fig. 567.

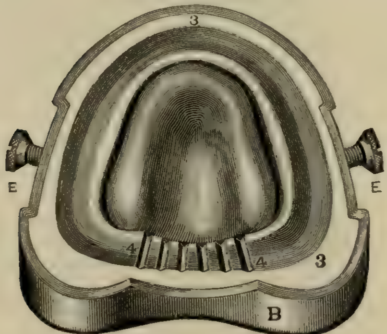


Fig. 568.

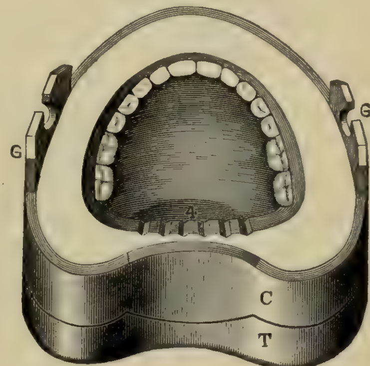


Fig. 569.

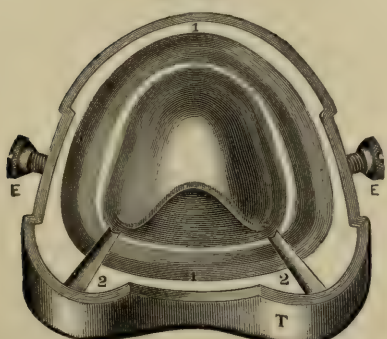


Fig. 570.

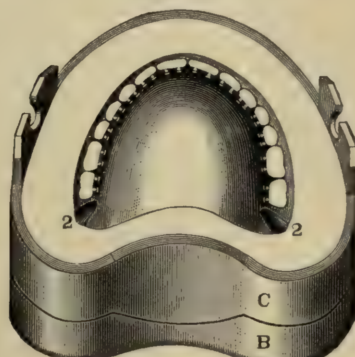


Fig. 571.

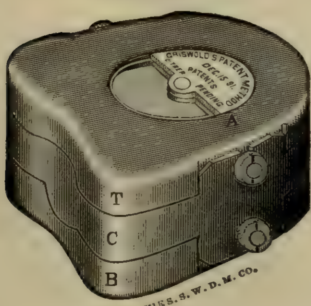


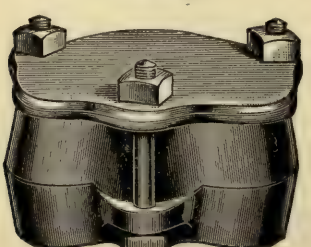
Fig. 572.

plaster to cover the ends of the teeth, and slope the plaster up from the palate edge to the centre *C* (rear edge, Fig. 568). Soap-lather the varnished plaster and waxed-up surfaces, lock the top *T* on the centre *C*, as in Fig. 569, and pour plaster through the hole in the top, jarring the flask to ensure its being filled, and turn the half disk to close the top.

After the plaster has set thoroughly, unlock, apply heat, and separate the flask, and cut grooves for surplus rubber, as shown in 1 and 2 in the top *T* (Fig. 569) and 3 and 4 in the base *B* (Fig. 567). Remove the wax with boiling water, lock *T* on *C* (Fig. 568), pack pink rubber neatly for labial and buccal gum surfaces, press *T* and *C* on *B*, and lock them together, as shown in Fig. 571. The top of the flask should not be removed nor grooves 1 and 2 cut until after the wax has been removed, the pink rubber packed, and the base locked to the centre, when *T* (Fig. 569) may be separated from *C*, *B*, and the red or black rubber packed under the teeth and over their backs and into the palatal part of the matrix (Fig. 571). A solution of soap is then applied to the palatal part of the top *T* (Fig. 570), which is placed on *C* (Fig. 569), and closed under the press and locked as in Fig. 571. If too much rubber has been packed to permit of closing, the soap solution used will prevent it from adhering to the plaster, and the section *T* may be safely separated from *C* to remove the excess of rubber: the flask may be closed, pressed, and locked for vulcanizing. The parts of this flask are accurately interchangeable, and by locking the centre *C* on the base *B* a deep base is formed for flasking partial cases in the way shown in Fig. 570, so that the artificial teeth are not separated from between the (natural) plaster teeth and cast at the risk of breaking the plaster fracturing or displacing the artificial teeth, but by packing and pressing the rubber from behind, and carefully pressing and locking the top *T*, Fig. 569, on *C*, Fig. 568, a partial denture may be moulded in which neither articulation or adjustment are disturbed."

There is a class of partial dentures constructed to replace the central and lateral incisors in young subjects whose front teeth have been lost through neglect or accident. In such cases it is often desirable to use sectional blocks of two teeth each, and to fit the gums directly upon the plaster, so that no rim of rubber may be seen in the finished piece. In such cases the flasking must be done in a way to allow the blocks to remain on the model and not be separated from between the plaster cuspids, otherwise the porcelain gums are very liable to fracture. The "Griswold flask" seems to be admirably adapted to cases of this kind.

Fig. 573.



Whitney flask (new style).

Fig. 574.

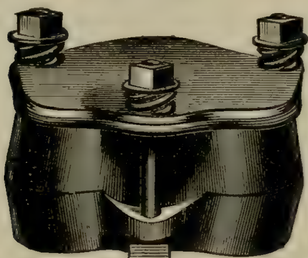
Whitney flask (deep). Size, $2\frac{3}{8} \times 3\frac{3}{16} \times 1\frac{1}{16}$.

Figs. 573 to 576 represent a few of the plainer forms of flask, some of which have been used with satisfaction for many years. The cuts give a good idea of their appearance and construction. Fig. 575 is the ordinary Whitney flask, with extra long bolts to accommodate spiral

springs, the purpose being to close the flask while it is in the vulcanizer by gentle and equable pressure. This procedure is, however, not recommended, as the parts of the flask should always be quite together before it is placed in the vulcanizer.

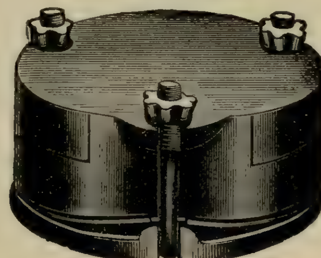
Fig. 575 represents the round "Hayes flask," of somewhat greater capacity than the others, and very convenient for flasking unusually large dentures.

FIG. 575.



Hayes flask. Size, $2\frac{3}{4} \times 3\frac{1}{4} \times 1\frac{3}{8}$.

FIG. 576.



Size, $2\frac{3}{4} \times 3\frac{1}{4} \times 1\frac{3}{8}$.

Fig. 577 is a flask of recent invention designed to avoid the annoyance caused by the stripping of the thread on the bolts. It consists of a flask and press combined: the press as seen in the cut remains *in situ* during vulcanizing. It has been further improved by the substitution of three screws set in triangle, instead of the single central screw. When the guide bars of vulcanizing flasks become deformed so that they no longer serve as true guides, the flask should be discarded.

FIG. 577.

Flasking.—The "waxed-up" model should be carefully trimmed, and saturated with cold water to prevent it from absorbing the water from the freshly-mixed plaster: the model should be tried in the empty flask to see that it is not too high or wide to be easily received by the latter. Plaster should then be mixed to saturation with water and poured into the lower half of the flask marked *B* (Fig. 578), and the model set into it. The practice of setting the model in the flask and then pouring the plaster in should be avoided, as there is always doubt about the plaster running under the model; and, unless the latter is completely bedded in the plaster, it will invariably break when pressure is brought to bear upon it in packing. The model should be allowed to stand as high as the case will admit without the teeth touching the top,

presuming, of course, that the case being flasked is an ordinary full denture, the object being to bring the line of separation *E* to the lowest part of the rim. When the plaster in *B* has set, it is to be levelled with the knife and given a coating of shellac or sandarac varnish, and then oiled or soaped as the operator prefers. The other half of the flask, *A*, is placed in position, the teeth and all surfaces wet to facilitate the flowing of the plaster, which is then carefully poured in the second section, care being taken to avoid air-bubbles and to work the plaster well against and between the teeth. The plaster should be allowed to fully harden before any attempt is made to separate the two parts of the flask, and this must not be done until the flask has been previously heated in

FIG. 579.

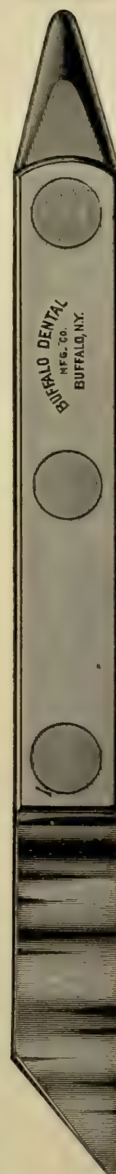
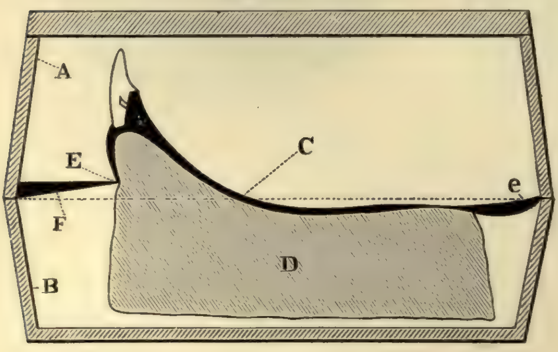


FIG. 578.



boiling water for the purpose of softening the wax, so that no resistance will be met with in parting the two halves of the flask *A* and *B*, and that the tin-foil covering to the gums and palatal portion of the denture will not be disturbed.

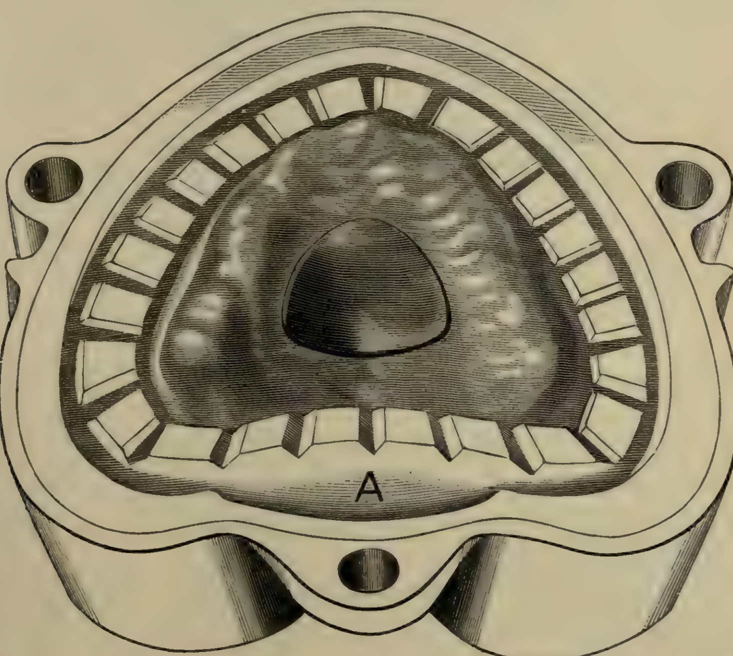
The next step is to clear the case completely of wax. If any of the latter is allowed to remain in the matrix or around the pins, it combines with the rubber and greatly impairs its strength and toughness; it is therefore necessary that the last trace of it be removed. This is most effectually done by pouring a stream of boiling water from the spout of an ordinary tea-kettle into the flask and over the teeth and wherever a trace of wax is visible. The flask should then be allowed to dry for a few minutes. To ensure absolute freedom from wax and the danger of shrinkage of the rubber from the teeth—a condition often due to failure to remove every particle of wax—the teeth and pins should be washed with strong alcohol applied with a camel's-hair pencil.

The Vents.—Fig. 579 shows a very convenient bench-knife for the cutting of vents, suggested by Prof. N. S. Hoff of Ann Arbor (Michigan University). It is made of one piece of steel, strong and well tempered. One end is tapered and thinned for removing plaster impressions from

casts and for the cutting of vents. The handle of the knife is of aluminum, and is therefore light and agreeable to the hand. The vents should be free, and sufficient in number and depth to readily admit of the escape of surplus rubber. The usual manner of arranging them is to cut grooves of about one-eighth of an inch in depth and about three-sixteenths of an inch apart, running out from the model to a somewhat deeper and broader groove cut entirely around the model, as shown in Fig. 580.

Another and perhaps better method is shown in Fig. 578, where it will be seen that the plaster in *A* has been trimmed away from the edge of the rim *E* of the denture to the border of the flask, deepening out toward the latter, *F*, to nearly one-eighth of an inch entirely around the model, as shown in the sectional view of the invested case. By this means sufficient pressure is retained on the case until the soft rubber has found its way into all the interstices of the teeth and plate, at the

Fig. 580.



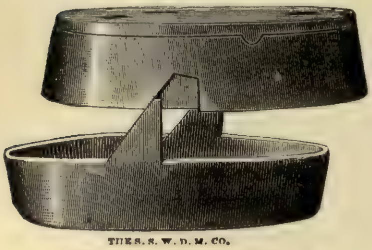
same time leaving ample gateway for the passage of all the surplus rubber, without the necessity for the application of much force, which might damage the model and strain the flask or force the rubber into the joints should gum teeth be used. When this method is used the two parts of the flask selected should fit each other perfectly and be in complete contact; otherwise the force required to press them together so as to distribute the rubber over all parts of the matrix may fall upon the teeth and model and cause fracture of one or both.

In cases where there are well-marked undercuts with projecting

alveolus in front the Campbell or Seabury oblique sliding guide-pin flasks should be used (Fig. 581).

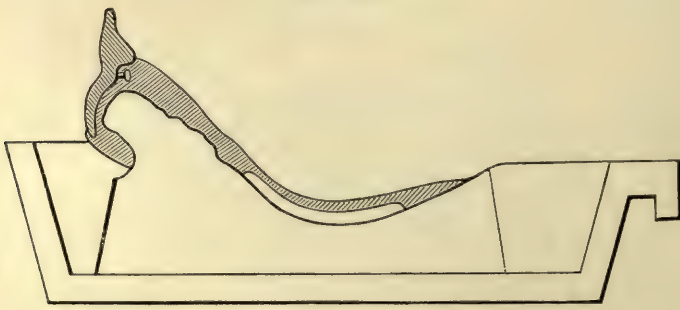
In flasking a case in which the model has a deep undercut in front the success of the subsequent details of the work and the safety of the denture will depend very much upon the line of division between the two parts of the flask. Reference to Fig. 582 will show such a case correctly invested, the plaster in the lower section covering the wax rim to within half a line of the porcelain gums. It will be seen readily that if the line of division had been made at the extreme upper edge of the rim, there would be danger of breaking off the projecting portion of the model in front on the separation of the flask.

FIG. 581.



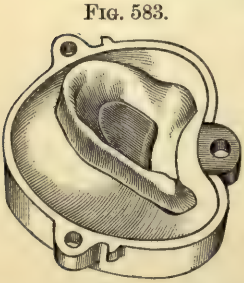
The Seabury dental flask.

FIG. 582.



Another method is represented in Fig. 583: it consists in trimming the model so that the axis of the undercut will assume as nearly as possible a perpendicular position in the flask. In all such cases the flask should be warmed in boiling water to thoroughly soften the wax before any attempt to separate the flask is made.

FIG. 583.

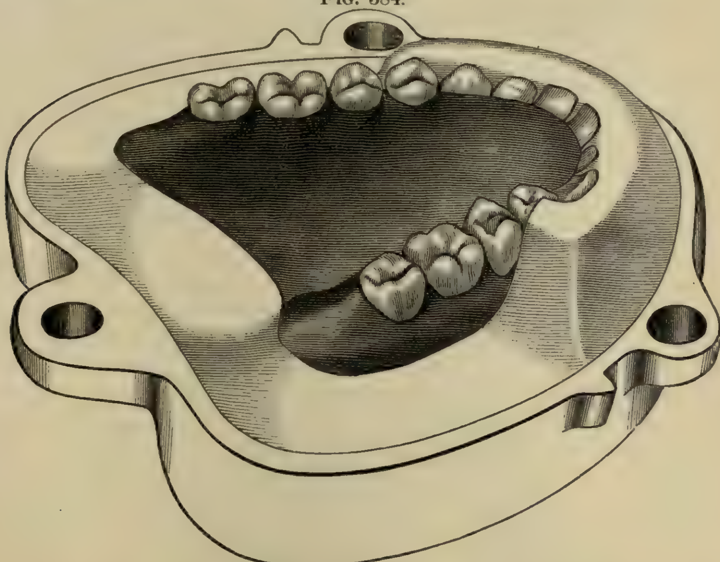


Should the undercut or projecting portion of the plaster model become broken, the success of the case is seriously imperilled; yet even such an accident may be repaired and the operation successfully completed. The wax is thoroughly washed from the model with boiling water; the flask is then allowed to dry for half an hour, when the broken piece may be fastened to the model by means of gum-tragacanth paste, and then reinforced by two thicknesses of tin-foil made to adhere by means of the tragacanth. Of course in such cases the subsequent packing must be done with unusual care: rubber cut in thin strips and warmed must be packed in that portion of the matrix representing the rim, as shown in Fig. 582, so that the broken piece may receive support from below. A very considerable surplus of rubber must be avoided,

and when the flask is quite together it must be separated and the broken piece examined to ascertain whether it has been forced from its place while the rubber was under pressure. If any change be observed, the piece can be readjusted, and by a small addition of rubber outside it may be held in correct position until after vulcanizing.

In cases where sectional blocks or single gum teeth are fitted to rest directly upon the natural gums in order to avoid unnecessary fulness, the division of the two parts of the plaster investment should be at the cutting edges of the teeth. By this means the teeth are securely fastened in their proper relation to the model in the lower section of the flask (Fig. 584).

Fig. 584.

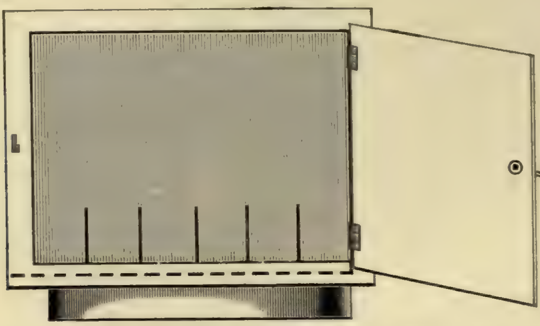


In all partial rubber cases where one or more gum teeth or sectional blocks are accurately fitted, so that they will, when the denture is inserted, rest directly upon the natural gums, the porcelain teeth must remain upon the model, and be secured there by the plaster which is described above, the investment should be brought to the cutting edges of both the artificial and the plaster teeth. The flasking of partial rubber cases often requires care and forethought. The student will do well to study the case closely if unusual difficulties appear, and endeavor to devise some definite plan which will seem to meet the requirements of the case.

Packing the Case.—The case being ready for packing, the two halves of the flask are put in a small steamer, which, as shown in Fig. 585, is a square tin box having a ring at the bottom for the purpose of placing it over any ordinary saucepan that will receive it. The box has a tight door and a portable perforated bottom resting over the ring, provided with bars or partitions standing about two inches in height and two and a half inches apart, running back to the full depth. By standing the halves of the flask edgewise, resting against the partitions, and

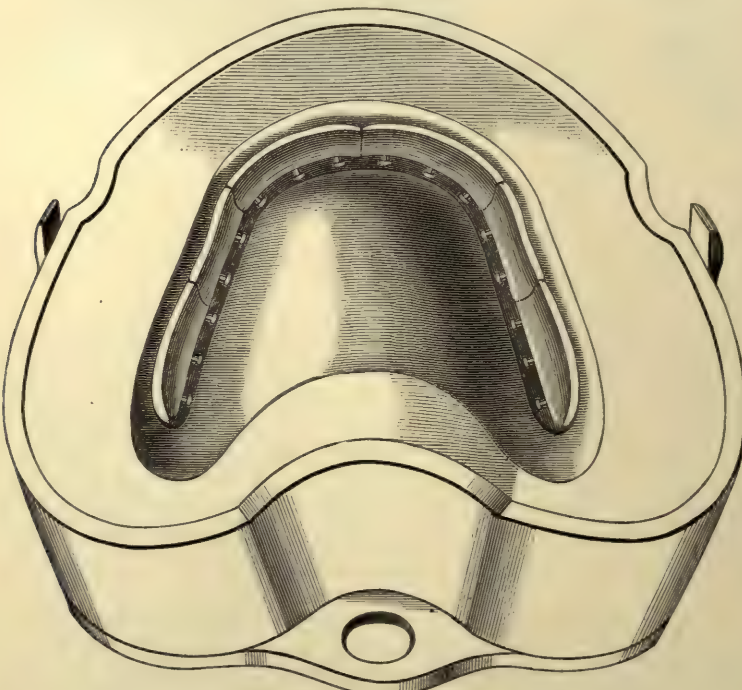
closing the door, the case is quickly steamed and made hot for packing. This arrangement, as above described, is very convenient, but any tin

FIG. 585.



or copper vessel in which water can be heated when provided with a top may be made to answer the purpose nearly as well. The top of the steamer can be used for warming the rubber: the latter should always be warmed and thoroughly softened before it is placed in the matrix.

FIG. 586.



Before packing the joints should be examined if gum or block teeth are used, and plaster mixed thin with water introduced into any open spaces in order to guard against the ingress of rubber. Zinc phosphate (oxyphosphate) cement, mixed thin and worked between the joints and

allowed to set, is recommended as a reliable means of preventing the rubber from being forced into joints.

Fig. 586 shows the upper section of the flask with the teeth in position. The model is then to receive a coating of No. 3 tin-foil to prevent the rubber from penetrating and adhering to its surface. The tin-foil is made to adhere to the plaster by means of thick tragacanth paste applied to the model with a suitable brush. The foil is cut into strips, laid upon the model, and lightly burnished to the surface. Tin-foil may easily be removed from the denture after vulcanizing with the finger-nail, provided the surface of the plaster model is hard and smooth; but if the plaster is soft and filled with minute air-bubbles, it will take such a hold upon the rubber that it can only be removed by the action of an acid. Either of the mineral acids except sulphuric will dissolve it, but as both nitric and nitro-hydrochloric act upon the rubber, the former quite energetically, neither should be employed: hydrochloric acid, though requiring a little more time in the solution of the tin, will effectually remove it without the least effect upon the rubber. The condition of the surface obtained by vulcanizing in contact with tin-foil is superior to that produced by the use of any other of the media usually employed for the purpose. Liquid silex and collodion are each extensively used for the same purpose, but the surface they afford is usually inferior to that formed under tin-foil. The correct method of using liquid silex is described as follows by Dr. Burchard:

"The solution known by this name, or as soluble glass, chemically the sodium silicate (Na_2SiO_3) is quite as effective a medium to prevent the adhesion of plaster to vulcanite as is tin-foil, but certain precautions are necessary to procure the best results. The material should be kept in a moderately warm place, and tightly stoppered. As soon as its viscidity becomes greater than that of a thin syrup, throw it away and buy a new bottle. Should it lose its perfect clearness, discard it. About one-third of the four-ounce bottles in which it is sold is useful; the remainder is usually so deteriorated as to be worthless. Dilution with hot water and warming the solution restore its appearance, but, for dental purposes, not its virtues. The model, after investment, and also the teeth and entire investment, are freed of adherent wax by pouring over them a stream of boiling water. The excess of water is absorbed by means of bibulous paper. As soon as the wet appearance disappears from the plaster it is ready to receive the silicate, not before.

"A camel's-hair brush, having a fine point and no loose hairs, is dipped in the solution and the surplus wiped off the brush. The plaster surfaces, all of them, are painted lightly with the silex, carefully avoiding contact with the porcelain or platinum pins. By means of the fine point on the brush the matrix of the rim is painted between the teeth; in coating the cap side of the investment, much care is required to prevent touching the teeth. Small wisps of bibulous paper are quickly and gently passed over the painted surfaces until there is but a thin glaze covering every part of the plaster. The pieces should be set aside for at least fifteen minutes, to permit thorough hardening of the silex. After vulcanizing the flasks should not remain unopened over night, for if salt (sodium chloride) has been used to hasten the setting of the investment,

the surface of the vulcanized plate will be covered by a hard and tenacrous glass; if opened as soon as cold the plaster and silex part from the vulcanite, without even washing, leaving a smooth, glazed surface equal to that found under tin-foil."

The mechanic may be certain that the lack of good results is due to either carelessness or faulty silex.

This is an important matter, as unquestionably many or most of the ills attributed to the wearing of vulcanite are due to roughness upon the palatal surfaces.[1]

The instruments used in packing rubber are very simple, a couple of blunt-pointed excavators being quite sufficient for the purpose. The operator should be very careful to have his steam-receptacle, flask, instruments for packing, and rubber all scrupulously clean, as the presence of wax, particles of plaster, or débris of any kind may seriously impair the work.

The quantity of rubber required to pack the case is governed by the thickness of the plate and the length of the bite. If the operator is not able to judge of the amount of rubber which should be used, he can very nearly approximate the proper quantity by gathering together every particle of the wax that was washed out from the flask and placing them in the glass measuring-jar containing water (Fig. 587). It consists of an ordinary tumbler, with a dished cover of spun brass, having a short flat tube soldered into a central opening. The trial-plate is put into the tumbler, which is nearly filled with water, so that when the cover is put on a little will overflow into it through the flat tube. The overflow is then thrown away, the trial-plate removed and replaced with rubber. When the water again stands at the top of the tube the gauge contains exactly the bulk of the trial-plate in rubber. The small sectional area of the tube, the only escape which is afforded to the water, render the guage very sensitive, and an exact measurement may be relied upon. The operation takes but a few minutes' time and will always afford accurate results. Another method of gauging the amount of rubber required is by weight. The specific gravity of brown rubber is about twice as great as that of the wax, so that twice the weight of wax in rubber has about the same volume as the wax.

FIG. 587.

Rubber gauge.

In packing plain teeth it is usually necessary to use pink rubber for that portion of the denture representing the gums: small pieces should be carefully packed between the teeth; a narrow band of rubber may then be laid along the outer edge of the necks of the teeth for the purpose of uniting the small pieces together, followed by larger pieces until the proper quantity to fill that portion representing the gums has been packed in. The dark rubber is then to be packed around the pins and over the palatal portion. The two are to be worked alternately, so as to

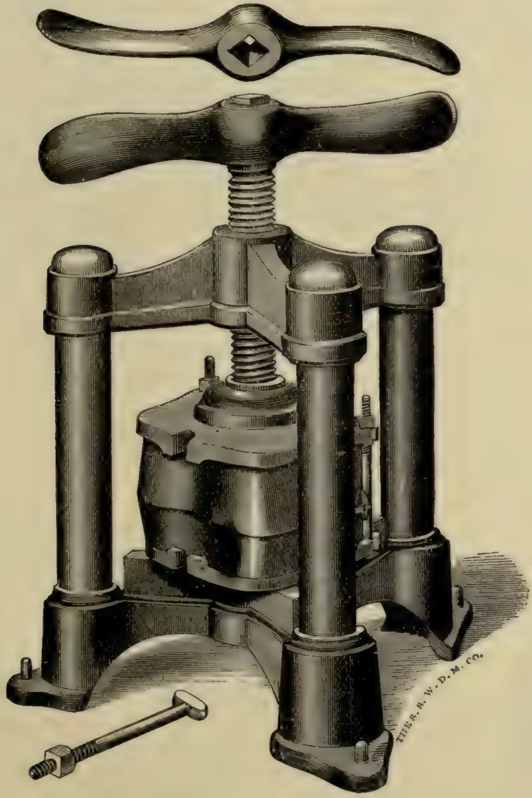
[1] H. H. Burchard, *Cosmos*, July, 1896.

have the pink sufficiently solid to prevent forcing the softer dark rubber through the pink by the final pressure, where it might show in the form of dark spots on the finished denture. The ability to accurately gauge the proportions will come with a little experience in this kind of work.

Should the base-plate wax be removed from the flask *en masse*, the amount of pink rubber required may be thus measured; that section representing the artificial gum is to be cut away and its volume determined in the water gauge. The pink rubber is then measured as above described. In these cases the amount of brown rubber is to be correspondingly diminished.

When the packing is complete the flask is replaced in the steamer, and

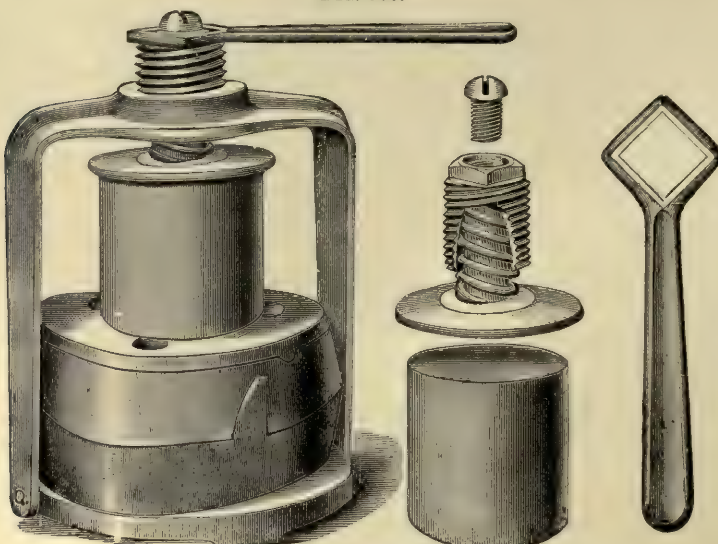
Fig. 588.



heated sufficiently to thoroughly soften the rubber: the two halves of the flask are then placed together, and closed by gradual pressure in one of the flask presses devised for that purpose. Fig. 588 illustrates one which has been used with satisfaction by the author. The screw should be turned very slowly, resting between turns to allow the rubber to spread and escape through the vents; otherwise there is danger of breaking away portions of the plaster investment, injuring the model, or of fracturing the sectional blocks when that style of teeth is used. When the two parts of the flask are quite together, it may be placed in a compress,

as shown in Fig. 589, and is then ready for vulcanizing, or in the ordinary bolt flasks the bolts may be adjusted and the flask secured by that

Fig. 589.

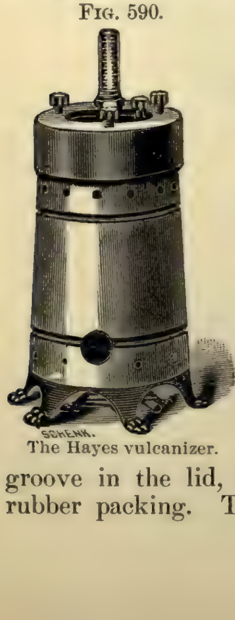


means. The use of bolts as a means of forcing the parts of the flask together in packing is objectionable on account of the liability to stripping of the thread after they have been used a few times: for this reason the press is gaining favor and the bolt flask will probably fall into disuse.

Vulcanizers.

There are in use at the present time many different forms of vulcanizers, each kind possessing more or less merit. It would be superfluous to enumerate them all: these descriptions will therefore be confined to the best and simplest examples of the somewhat extensive list. The older form is shown in Fig. 590. The later forms are built after different plans. Among these latter the A. C. Davis, and the Lewis cross-bar vulcanizers appear to possess the requirements of a good apparatus.

Fig. 590.



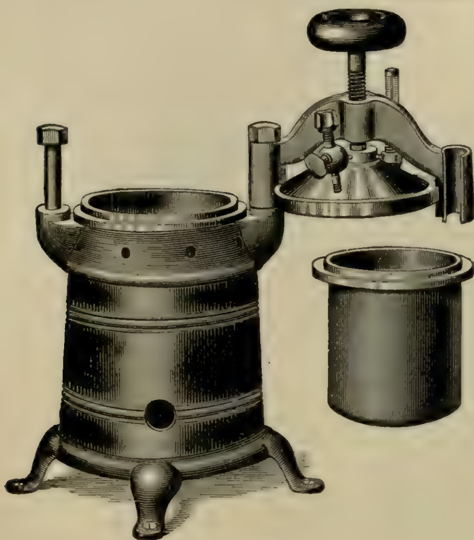
The Hayes vulcanizer.

The Davis vulcanizer (Fig. 591) is strong and simple in construction. One hand only is required in tightening or loosening the lid, which is entirely independent of the hot chamber.

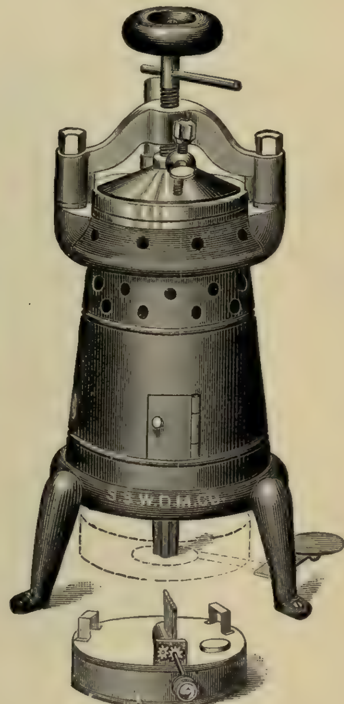
The boiler or hot chamber is made of heavy seamless copper; around the top a brass ring is brazed, forming a shoulder which rests upon a steel collar bolted within the jacket to the base. The edge of the boiler fits neatly into a circular groove in the lid, tightness of the joint being secured by means of rubber packing. The boiler is readily lifted out for emptying.

The lid is controlled by a centre screw and two side-guides on the arms of the yoke or cross-bar. The cross-bar is pivoted by its upright arm at one end to the steel collar which supports the boiler, the

FIG. 591.



For gas or alcohol.



For kerosene.

other arm being slotted to straddle a stop at the opposite side of the collar. This pivotal cross-bar by means of a screw-bolt passing through its centre carries the lid of the boiler, the bolt being operated by a wooden hand-wheel, and, when necessary to screw tighter than the wheel, a pin wrench is provided which can be passed through a hole in the screw-bolt. The thermometer and safety-plug are secured to the lid. The centre screw with side-guides makes the movement of the lid exact, and the advantages of the swinging cover will be at once apparent to those who have experience in the use of vulcanizers. As shown by the illustration, this vulcanizer is adapted for gas, alcohol, or kerosene.

The Lewis cross-bar vulcanizer (Fig. 592) is entirely new in its essential parts, and embodies many valuable improvements, and is probably one of the strongest, safest, and most convenient vulcanizers of the cross-bar pattern in use.

The boiler is hand-made from copper rolled expressly for this form of vulcanizer, and is of unusual thickness. The cap is ribbed on the under side to resist any strain which may be put upon it. This cap has but two holes drilled in it, one for the mercury bath, to which the thermometer is attached; the other for the "manifold," which carries the safety-valve, blow-off, gas-regulator, or steam-gauge (Fig. 593). The ring surrounding the boiler is of cast steel, and is therefore of ample strength. Besides the lugs for taking the strain off the cross-bar and

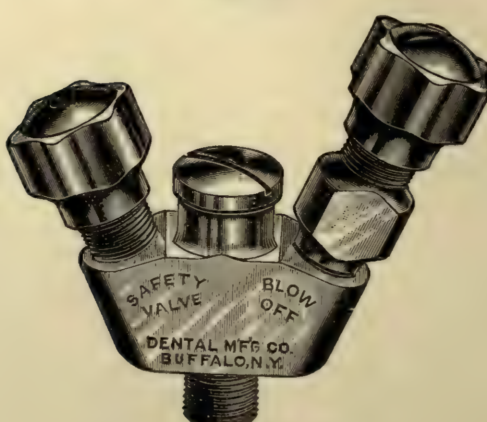
bolt, it has a dovetailed projection for the insertion of a lifting handle (Fig. 594).

It will be observed that when the cross-bar and cap are removed there are no swinging bolts or attachments to the pot.

FIG. 592.

Lewis cross-bar vulcanizer, with gas heating apparatus.

FIG. 593.

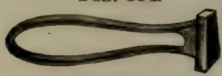


The cross-bar is of an improved form, and is also made of cast steel. One end is at right angles to the main bar, and terminated by projections which catch under the lugs on the ring. Over the projections is a small

rib which prevents the bar from dropping out of position. The other end of the cross-bar has an enlarged portion for the reception of the bolt, and is terminated by a handle.

The vulcanizer is closed by one bolt suspended in a slot on the hand-end of the cross-bar. The bolt is squared to prevent rotation, and is

Fig. 594.



Pot-lifter.

Fig. 595.

Cross-bar wrench.

surrounded by a spring for the purpose of disengaging it from the lugs when the nut is slackened off, and for always retaining the bolt perpendicularly and forcing it in place automatically.

The vulcanizer is opened by loosening the nut on the bolt by means of the wrench furnished for the purpose (Fig. 595). The bolt will be forced downward through the action of the spring. The handle of the cross-

Fig. 596.

bar is then seized, and with the thumb against the nut it is pressed until the bottom of the bolt is disengaged from the lugs, when the bar may be lifted (Fig. 596).

The Seabury Vulcanizer.—This apparatus is so arranged that the vulcanizing is accomplished with dry steam. It has a dry chamber or oven for vulcanizing, which is distinct from the steam-generating chamber or boiler, the two being connected by a valve cut-off. The vulcanizing chamber has a capacity of three flasks. In the illustration the jacket is cut away to show the relative positions of the two chambers, and their connection. It is claimed for this machine that plates made in it are as strong when only half as thick as when vulcanized in the ordinary way.

By cutting off the steam from the generating chamber cases can be removed and others inserted without loss of time, and, as the plaster is

Fig. 597.

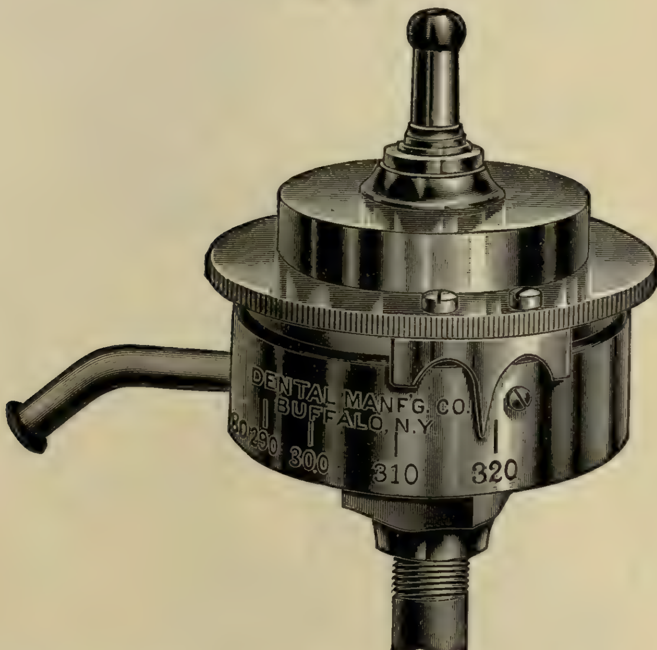
but slightly injured by the dry steam, warping of plates by the yielding of the investment is not likely to occur.

General Instructions for Attaching and Connecting Gas and Time Regulators.

The gas regulator (Fig. 598), if not already attached to the vulcanizer, is secured to the cap by means of the short iron pipe or coil. This is screwed into a hole drilled through the cap of the vulcanizer. Any gas-fitter or machinist can connect the regulator to the cap if he has what is known as a "one-eighth gas-pipe tap." If the vulcanizer has a "Lewis manifold" attached to the cap of the vulcanizer, remove the screw between the blow-off and safety-valve and screw the coil-pipe in its place. After the gas regulator has been properly fitted, place the vulcanizer in the jacket and in the position in which it is to be used. Connections between the time regulator, gas regulator, and gas burner are made by means of rubber tubing. The engraving (Fig. 599) illustrates the correct method of connecting gas and time regulators to vulcanizers. Cut

a piece of tubing of sufficient length to reach from the gas-supply tap to the *time regulator*, and connect them; cut off another piece to reach from the time regulator to the *gas regulator*, and attach to gas regulator by the *upright* or straight nipple on top of the No. 4 Lewis gas regulator; then connect the downward curved tube of the gas regulator to the gas burner under the vulcanizer with another piece of rubber tubing.

FIG. 598.



The time regulator is more convenient when placed on a bracket near the gas-supply pipe. It is then out of the way, and not likely to be broken from contact with tools, and can also be used as a time-piece.

"*To Set the Time Regulator.*—When the valve lever on top of the time regulator (Fig. 600) is engaged with the screw upon the minute arbor on the back of the clock, the valve is held open for a length of time depending upon whether the lever is engaged with the first, second, or third thread of the screw; and the lever will be cast off, and the valve closed when the minute-hand reaches the figure XII. When the minute-hand is at IX the lever will be cast off at the end of fifteen minutes if it is engaged with the *first* thread of the screw from the end; an hour and a quarter, if engaged with the *second* thread, and so on. A trial should be made, and the time ascertained which is necessary for heating the vulcanizer to the vulcanizing point, and this time should be added to the proposed time for vulcanizing. We have, therefore, the following

"RULE.—Turn the minute-hand to as many minutes *before the hour* as the number of odd minutes desired; then put the end of the

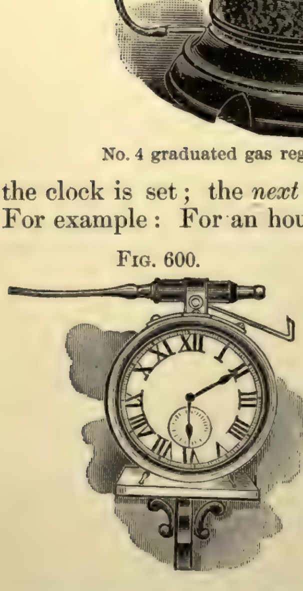
lever in the threads of the screw upon the minute arbor at the back of the clock. The *first* thread from the end gives the odd minutes to which

FIG. 599.

No. 4 graduated gas regulator, mounted on a Lewis cross-bar vulcanizer.

the clock is set; the *next* and *each* succeeding thread gives a full hour. For example: For an hour and twenty minutes set the minute-hand at the figure VIII, and engage the lever in the *second* thread from the end of the screw. At the end of that time the lever will disengage and automatically shut off the gas from the vulcanizer. If this were to be an hour longer—*i. e.* two hours and twenty minutes—the lever should be placed on the third thread of the screw.

FIG. 600.



"Those who use vulcanizers should be thoroughly informed as to the nature and properties of steam. The fact should be borne in mind that a vulcanizer is subject to the same laws and conditions as a steam-boiler, which it is in fact; and, although it is comparatively safe and

easily operated, it may, by carelessness or ignorance in its management, become almost as dangerous as a bombshell.

"The following table of steam-pressures will be found convenient for reference, as it has been corrected so that it shows the true temperature for any pressure indicated by the steam-gauge. Fractions are omitted, and the nearest whole numbers used instead. The French table generally used shows 14.7 pounds pressure at 212°, whereas the steam-gauge at that temperature will indicate 0, unless by the expansion of heated air confined in the vulcanizer. The gauge is therefore just *one atmosphere* lower than the French table:

Table of the Elastic Force of Steam (corrected to correspond with the steam-gauge).

Degrees of temperature, Fahrenheit.	Elastic force in lbs. per square inch.	Degrees of temperature, Fahrenheit.	Elastic force in lbs. per square inch.
212	0	390	205
220	2	400	234
230	6	410	264
240	10	420	296
250	15	430	335
260	21	440	375
270	27	450	415
280	34	460	455
290	43	470	515
300	52	480	565
310	63	490	603
320	75	500	663
330	89	510	721
340	104	520	793
350	120	530	864
360	140	540	937
370	160	550	1015
380	180		

"It will be noticed that as the temperature rises the pressure of steam increases in a constantly increasing ratio for equal increments of heat, the pressure being nearly doubled by the addition of fifty degrees to the temperature. This fact will show the *necessity* of care and watchfulness while vulcanizing.

"The bulb of the thermometer is set in a mercury bath. This is the small cup, forming a part of the vulcanizer cap, to which the thermometer case is screwed. This cup should contain sufficient mercury to ensure its touching the bulb of the tube when the thermometer case is screwed down properly. This makes a *metallic connection* between the thermometer bulb and the vulcanizer cap, and is *absolutely necessary* for the proper indication of heat by the thermometer.

"Should the mercury column separate, it can usually be reunited by removing the tube from the thermometer case, holding it perpendicularly, and striking the bulb with some force upon the palm of the hand, or by holding the tube by the bulb and giving it a sudden flirt. If the vulcanizer is used with the thermometer in this condition, it should be remembered that it is the *whole column* that denotes the heat, and allowance should be made for the broken part; *i. e.* if there is enough mercury separated to fill the space of ten degrees, the remainder of the column should only rise to ten degrees less than the temperature desired.

"Directions for inserting a new tube in the thermometer case will generally be found on the package containing the tube and scale.

"Thermometers are accurately marked, by test instruments, at the 212° and 320° points, and the scales are especially graduated for each tube, as the positions of the points above named vary in different tubes. *Each tube must, therefore, be used with its own scale*, and in fitting it to the case care should be taken that the black mark on the tube indicating the 320° point is brought exactly opposite to the 320° point on the scale.

"The thermometer does not always give a correct indication of the heat of the vulcanizer. It only gives the temperature of the vulcanizer top, which may not be that of the flask. In fact, the indications of the thermometers employed on vulcanizers are almost invariably too low, owing to imperfect conduction of heat, radiation, etc.; and the vulcanizing temperature, instead of being 320°, as indicated, is more usually 330° to 340°."

The plan of providing a mercury bath for the reception of the bulb is a great improvement over the old way, and prevents the fracture of the bulb by the great pressure of the steam, which was of such frequent occurrence when the thermometer was in direct contact with the latter.

Damage to the glass bulb of the thermometer is manifested by a rise in the mercury, which cannot be brought down to the usual vulcanizing point by turning off the flame of the burner; consequently the thermometer ceases to correctly indicate the degree of heat, and imperfect vulcanization is the result. Leakage of steam around the packing of the vulcanizer should also be guarded against, as in such cases all of the water may escape from the apparatus before the vulcanizing is complete. Loss of all of the water in the vulcanizer may be detected by a persistent fall of the mercury, even when the gas flame is greatly increased, and when this phenomenon is observed the gas should be turned off, the vulcanizer allowed to cool, and new packing adjusted.

Failure to strictly observe this rule has undoubtedly resulted in many serious accidents. An example of this kind occurred some years since in the laboratory of the dental department of the University of Pennsylvania. A student was endeavoring to vulcanize with an apparatus which leaked at the packing: noticing that the mercury persisted in falling, he continued to increase the gas flame until the lower part of the vulcanizer was probably red hot. While he stood before it, holding a lighted match to the tube to enable him to see the column of mercury, the vulcanizer exploded with terrific force, sending the top through the ceiling and pieces of the boiler in every direction. It is quite likely that in this particular case the steam was partly decomposed by contact with the hot metal, producing a highly explosive combination of oxygen and hydrogen: no other theory would seem to account for the great force of the explosion.

Having described a few of the different kinds of vulcanizers and their relative merits, we should next consider how to use them.

The flask or flasks, being ready, are placed in the vulcanizer and filled with clean water to within an inch or two of the top. The packing should be smooth and sound; a suitable separating material must be applied to the latter to prevent adhesion; the joint between pot and cover must be absolutely steam-tight. A slight coating of black lead, soap-

stone, or soap will accomplish the desired result, preference being given to the black lead. The cover is then put on as directed for the different kinds of vulcanizers; the valve is opened and allowed to heat up until a slight leak of steam takes place: this is to allow all air to escape before steam generates; then close the valve and vulcanize, watching the pressure carefully if there is no automatic regulator, so as to keep an even temperature, otherwise the work will not be perfect.

Fig. 601.

Fig. 601 shows a useful form of flask-tongs for lifting flasks from the vulcanizer. They are made of sufficient length to reach the bottom of a three-case vulcanizer, and will securely grip the flask.

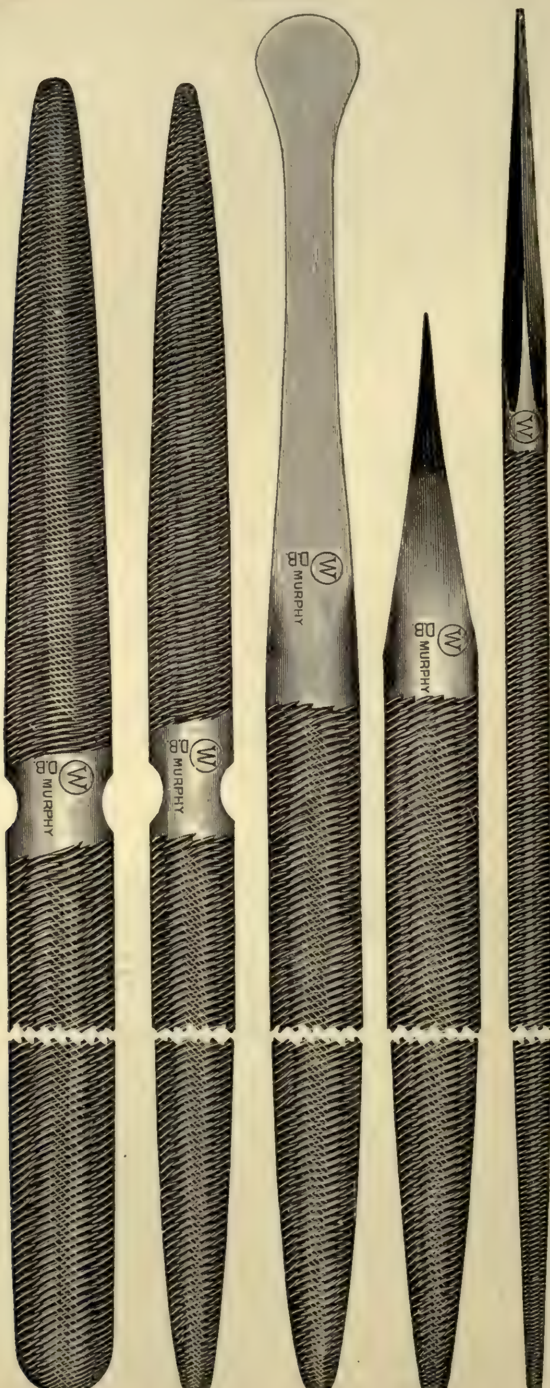
Finishing Process.—After vulcanizing, the flask containing the rubber denture should be allowed to cool gradually and completely, care being taken not to open the flask while the least warmth remains in the plaster investment, as failure to strictly follow this rule will result in warping of the plate. The flask must be opened with care, and the plaster cut from around the teeth before attempting to remove it from the flask; otherwise a tooth may be broken or a block cracked by the use of unnecessary force. This is, in fact, the most common of causes in block fracture. All traces of plaster should then be carefully removed, first with a suitable plaster-knife, and lastly with a brush and water. The plate is then ready for trimming and polishing.

Fig. 602.

Showing vulcanized piece as it comes from the investment.

In finishing the piece the surplus rubber or vents should be removed with a jeweller's saw. The buccal, labial, and palatal edges are then to be filed to the proper line, which is generally marked on the

Fig. 603.

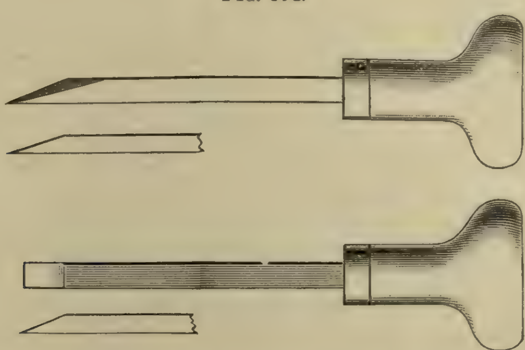


model with a sharp instrument before the teeth are mounted, and which, showing on the plate after vulcanizing, serves as a guide to the workman in trimming the edge of the vulcanized piece. Fig. 603 illustrates a few desirable forms of files for rubber work.

The palatal portion and labial surfaces of the plate will need but little finishing if the preliminary waxing has been well done. Fig. 602 shows a lower vulcanite denture as it should appear before any attempt at finishing has been made. It will be seen by this illustration that no carving or scraping is necessary, shape and form having been secured in the wax. The correct thickness of the denture should always be provided for in the temporary wax-plate. A few scrapers of good form, size, and temper will, however, always be needed for the removal of excrescences which may be present in consequence of defects in the plaster investment, and for this purpose the vulcanite scrapers designed by Dr. N. W. Kingsley will be found to answer admirably. As shown in Fig. 605, they are superior to the ordinary scraper. The handles are gracefully formed to suit the hand and steady the blade in using its edge to cut instead of scrape. The tool has a rounded or convex back, with thin edges: it will not cut in, but will remove superfluous material and carve the surface smoothly and rapidly.

Two or more gravers of the forms shown in Fig. 604 are indispensable for trimming around the necks of the teeth and carving the festoons of the gums. These gravers should be of a light straw temper, as they

Fig. 604.



require considerable hardness to enable them to retain a keen edge while trimming around the necks of the porcelain teeth. They must be kept as sharp as possible, so as to make a clean and smooth cut which will require no additional finishing.

When the filing and carving and unavoidable scraping are finished, the surfaces thus worked over will require additional smoothing with fine emery- or sand-paper of the grade of No. 0 or 00, or a piece of quick-cutting Scotch stone, kept wet and armed with fine pumice-stone, followed with a stick of poplar or pine wood and pumice and water, will produce a surface quite ready for the final polishing on the lathe. Many materials have been recommended as scratch-eliminators, and one of the simplest and most effective is formed of an ordinary champagne cork screwed on to the revolving screw-chuck and cut down to the desired size and shape

with a pen-knife, and worked with wet pumice. Other materials, such as felt, cotton cloth, and leather, have been used for buff wheels in the finishing of vulcanite dentures. An excellent set of composition cones and wheels have recently been introduced, and have been found to be quite equal to any of their predecessors. These are shown in the annexed cut.

FIG. 605.

These buff wheels, used with pumice, are not intended for obtaining high lustre: they are employed to produce a condition of surface suitable for the final polish, which is obtained by means of fine brush wheels armed with chalk or rouge.

An extra fine surface can be given the plate by using various sized cones formed of moose hide armed with oil and rotten stone, but the application of the latter should precede the chalk finish.

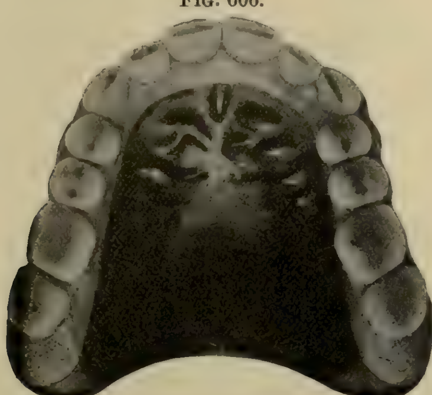
It is not necessary, of course, to employ all of the appliances herein enumerated: any of them, when used with skill and judgment, will produce good results. It should be borne in mind that no attempt to obtain a faultless surface will be successful until all tool-marks and scratches have been first eliminated by rubbing the surface with fine emery-paper and pumice applied with a soft wooden stick. The latter method is particularly effective in smoothing irregular surfaces where it is desirable to avoid obliterating rugæ and other imitations of natural prominences of the mouth, as a slightly sharpened stick will easily carry the abrading powder into deep places which would be inaccessible to the buff or brush wheel.

After using the felt buff wheel, which should follow the stick, the surface may be further improved by using a coarse bristle-brush with pumice, kept freely wet with water. The final polishing is done with a soft bristle-brush with prepared chalk, sparingly moistened with water, running the lathe at the highest attainable speed. Care is required in buffing and polishing operations on the lathe to avoid heating the plate by the friction of the rapidly revolving wheel. Plates are often warped from this cause, but by the use of plenty of cold

water during the pumicing and the precaution to avoid too forcible and steady pressure during the final polishing no such accident need occur.

The **ebonite plate** (black rubber), with the gum portions or fronts formed of pink rubber, generally requires two vulcanizings in its construction, and when tastefully modelled and arranged the combination of the two rubbers is capable of affording a most artistic imitation of a natural denture. A single sheet of thin paraffin and wax is warmed and worked over the model; the edges are trimmed to the exact size required for the finished plate; a narrow strip of wax is then cut from a sheet of wax to the width and thickness of one-sixteenth of an inch, warmed gently, and laid around the outside buccal and labial edge and along the palatal portion of the plate just back of the alveolar ridge. With a heated spatula this guard-strip is blended on the palatal side with the plate. It is then invested, packed, and vulcanized. In vulcanizing black rubbers the temperature should be raised very slowly to 320°. The edges are to be dressed and the plate partially finished, and that portion between the projecting borders which is to receive the teeth and pink-rubber gums should be roughened thoroughly with a sharp-pointed instrument or knife-point, for the purpose of ensuring a strong union between the pink and black rubbers. The plate is then ready for the articulation, which is taken in the usual way, after which the teeth are selected and fitted : the case is waxed

FIG. 606.

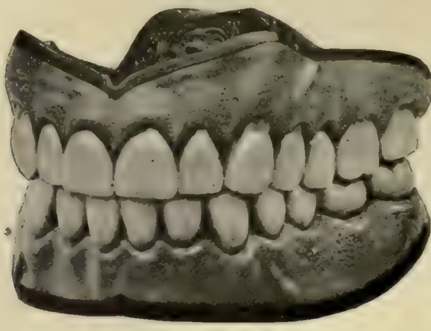


up and invested in a flask. When the latter is separated and the wax thoroughly removed, the surface which is to be covered with the pink rubber should be given a coating of a solution of pink rubber dissolved in chloroform, of the consistence of thick cream : this is done to further strengthen union of the two rubbers. The piece is then ready for packing and vulcanizing. In flasking such a case the entire palatal portion of the plate should be covered with plaster to prevent it from warping during packing, which otherwise would be liable to occur in consequence of the slight elevation of temperature required to soften the pink rubber sufficiently to admit of perfect closure of the flask. This method is illustrated by Figs. 606 and 607.

Partial Cases.—It frequently occurs in constructing partial artificial

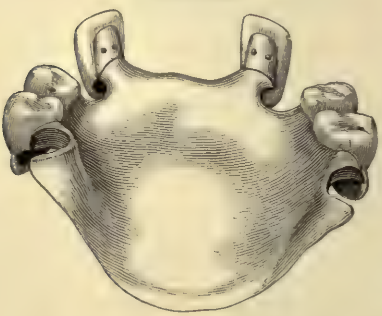
dentures for the replacement of single incisors or cuspids that the ordinary rubber teeth are too thick to admit of their being arranged to con-

Fig. 607.



form to the line of the natural teeth without interfering with the normal occlusion (Fig. 608). In such cases a plate tooth may be used, and attached, by means of gold backings bent at an angle with the base of the tooth, of sufficient length to allow of the projecting portion being imbedded in the rubber plate, as shown in Figs. 608 and 609. The extension of the gold backing should in Fig. 609 bear two or more holes punched and countersunk in it, so as to be firmly held by the vulcanized rubber.

Fig. 608.



Gold clasps where used in combination with rubber are attached in the same way. The clasp, after being accurately fitted to the plaster tooth, is provided with a piece of gold plate soldered at a point next to the rubber plate (Figs. 611–614). This attachment should be slightly raised from the model, so that it will be entirely enveloped by the rubber as shown in Fig. 611.

Fig. 609.

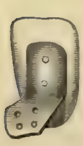


Fig. 610.

Fig. 611.

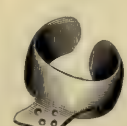


Fig. 612.

Fig. 613.

Fig. 614.

There is some danger of these clasps being forced slightly from their correct position by the pressure of the rubber in packing: this difficulty may be entirely overcome by soldering a temporary support of scrap gold to the clasp and bending it over the plaster tooth, as shown by Fig. 613. Usually this device will be found to be effective in retaining

the clasp in contact with the tooth. After vulcanizing, the supporting piece of gold may be sawed off with a jeweller's saw. In packing a case arranged with gold clasps a thin sheet of rubber should be worked under the gold attachment to further protect the latter from displacement. It will of course be understood that the clasps are to remain in position during the packing; therefore in flasking such cases the plaster should be made to cover the portion of the clasp not actually in contact with the rubber: this affords additional support to the clasp during the pressure accompanying the closing of the flask in packing, and will keep it in its correct relation to the plaster tooth.

Partial Lower Vulcanite Dentures.—Gold is used in combination with that class of partial lower dentures designed to replace the bicuspids and molars, and when the natural incisors and cuspids remain. For the purpose of strengthening the piece and to lessen its bulk in front a plate of gold is sometimes swaged to fit the model back of the front teeth, and where the ridge is not well defined and not favorable to the retention of the piece without some form of attachments, gold clasps are soldered. The gold plate is allowed to extend somewhat beyond the cuspid teeth; the ends are perforated by the punching forceps, as shown by Fig. 615, to ensure strong union with the rubber. This plate is then put upon the model and secured in place by means of wax; the teeth are arranged in position, waxed up, and vulcanized in the usual way. The denture when finished presents to view a plate with the anterior part of gold, while the two parts holding the teeth and resting upon the ridge on each side are of vulcanite. The purpose of such a combi-

Fig. 615.

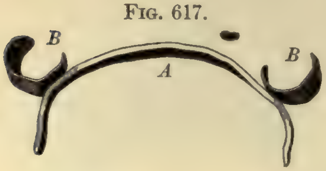
Fig. 616.

nation is to save labor and material, but a denture so constructed, while better in point of durability and the absence of bulkiness where it passes around back of the incisors and cuspids than vulcanite alone, is still far inferior to one constructed entirely of gold, for while such a

denture is doubtless stronger than one of vulcanite alone, it is not so durable as one made exclusively of gold, on account of the liability of the piece breaking at the points where the gold is imbedded in the vulcanite. Dentures of the class above referred to should always be made entirely of metal, and the expenditure of money and labor is but little greater than in the combination plan, while the general result is in every way more satisfactory.

A simpler, though somewhat inferior, method frequently resorted to in order to strengthen partial lower vulcanite dentures and to afford means of attaching clasps is shown in Fig. 616. It consists in imbedding a gold or platinum wire (Fig. 617) back of the front teeth at *A*, to which clasps are soldered, as shown in *B* (Fig. 617). The objection to this arrangement is that it does not reduce the bulk of the piece to any great extent, while it adds but little to its strength.

FIG. 617.



Still another method is by covering that portion of the lingual surface of the plate back of the natural teeth with the perforated plate of Wunsche. (See p. 531.)

Where the anterior natural teeth have become so loosened by the ravages of pyorrhœa alveolaris, excessive absorption of the gums and sockets or of the roots of the teeth, that their complete loss is a matter of a very short period of time, a plaster impression may be taken of the mouth before the removal of the loose teeth.

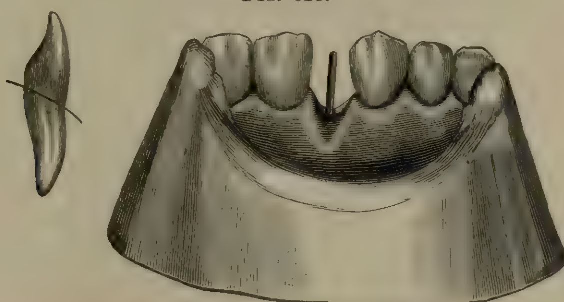
In such cases the object is to obtain an accurate plaster impression of the mouth which shall include the loose teeth, and this should be done without the exhibition of sufficient force to cause pain to the patient or to disturb the infirm and tender teeth. This result may be attained by selecting a quite new impression-cup of proper size and form, oiling the surface before the plaster is placed in it, and then proceeding in the usual way. When the plaster is sufficiently hard the cup, in consequence of its smoothness of surface and the oil applied as a separating medium, may be removed with very little force. This leaves the plaster impression intact, and its removal must be accomplished by breaking it into sections with the thumb and index finger, beginning with the portion covering the labial surfaces of the incisors, and then removing the plaster covering the buccal surfaces of the bicuspids and molars. These pieces are to be correctly assembled in the impression-cup in the manner more fully described in the chapter on Taking Impressions, and the model obtained in the usual way. The plaster facsimiles of the infirm teeth are then to be cut from the model at the margin of the gum with a jeweller's saw or suitable knife-blade, and the plaster is to be scraped away to the depth of three-sixteenths of an inch, so as to represent the appearance of the socket immediately after the removal of a natural tooth.

In constructing partial dentures for cases where the natural organs are prematurely lost it is much the better practice to reset the natural teeth,[1] provided, as is often the case, they are of dense structure and have not previously been attacked by caries. This is done by making

[1] Method of resetting natural teeth, p. 429.

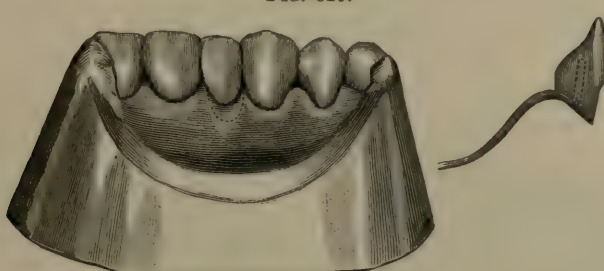
a plate in the usual way, and in the space or spaces to be occupied by the natural teeth vulcanizing a strong platinous gold wire, being careful to place the gold pin in the centre of the space. The wire must have an attachment soldered to it, so that its connection with the rubber will be secure. The wire may be arranged with a simple piece of scrap gold soldered to the end to be imbedded in the rubber, as shown in Fig. 618, or it may be provided with a perforated extension, as shown in Fig. 619, by which union with the rubber may be secured and great bulkiness avoided. The rubber portion of the denture finished, it only remains to remove the infirm natural organs and attach them to the plate made ready for their reception. This is done by sawing off the roots (Fig. 618), enlarging the pulp-canal with a suitable engine drill, fitting the neck of the tooth to the plate, and into the socket, as shown in same figures, and then attaching the tooth to the pin (Fig. 619)

Fig. 618.



and plate by means of zinc-phosphate cement, being careful to dry the parts thoroughly before the cement is applied. This method of resetting natural teeth is more conveniently done on gold plates than on those of rubber, but it is applicable to both. It possesses the following

Fig. 619.



advantages: First. The teeth are the patient's natural teeth, and this fact very greatly lessens the repugnance which many individuals of exalted sensibilities feel to artificial teeth. Second. It saves the individual from being seen without teeth—a matter of the greatest importance to many patients. Third. Artificial appearance is avoided, for they are the natural teeth of the patient, and nothing more need be said on the score of natural effect. The question is often asked, Do teeth reset in this

manner suffer from dental caries? It has been observed that such teeth are not more liable to decay after their attachment to a plate than they were before removal from their sockets.

It might be thought that irritation of the freshly wounded alveoli would be caused by the teeth covering and to some extent entering them; on the contrary, wounds incident to extraction heal more rapidly when covered by a denture than when left quite open.

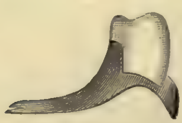
If the infirm natural teeth are of poor quality and have large fillings in them, it is better to use porcelain teeth, and the dentures can be entirely finished ready for insertion before the natural teeth need be extracted. Care should be observed to allow the necks of the artificial teeth to extend well into the sockets of the extracted organs, to anticipate absorption of the parts which to some extent is sure to occur at such points.

In all partial upper dentures, wherever practicable, the teeth should rest upon the natural gum, and where excessive absorption has occurred and fulness is demanded, gum teeth are preferable to the use of pink rubber.

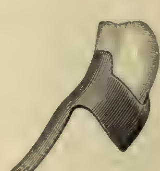
When dentures are inserted soon after extraction the use of plain teeth is invariably indicated, especially at the anterior portion of the mouth, including the incisors and cuspids. These should be ground to fit the gum accurately, and to ensure close adaptation, the plaster model should be slightly scraped away at the points where the necks of the teeth rest upon it. In flasking cases wherein the teeth rest directly upon the plaster model it is well to arrange the plaster investment so that the teeth may remain *in situ* during the packing—*i. e.* in the lower section of the flask and not separate from the model by the removal of the second half of the flask, as is usually the case.

Repairing Rubber Plates.—Breakage of vulcanite dentures is usually due either to over-vulcanizing, by which elasticity and toughness are destroyed, or to improper arrangement of the molars, by which the strain of mastication is thrown on the outside instead of on top of the ridge, as shown in Figs. 620 and 621.

Figs. 620 and 621.



Correct way.

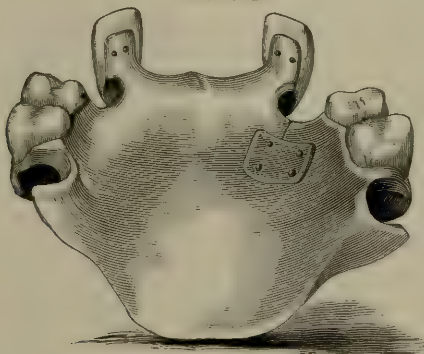


Incorrect way.

The first evidence of the giving way of the piece is usually a fine crack appearing between the two central teeth, and sometimes, in partial dentures, in the border surrounding a natural tooth, as shown by Fig. 622. A break of this nature may be repaired by riveting a neatly-fitting piece of stout platinous gold plate over the crack, as shown in same figure. The rivets should be of 18-carat gold wire, of the size of No. 16 of the standard gauge, and the holes for the reception of the rivets should be countersunk on both sides. After annealing the wire it should be screwed in a hand vise, so that a head may be formed upon the end by spreading

the metal with a small riveting hammer: the wire is then passed through the rubber and the gold plate, the head portion of the pin resting in the

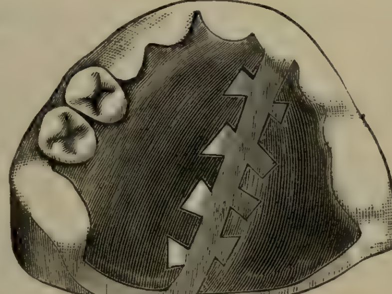
FIG. 622.



countersunk portion of the vulcanite plate. After cutting off the wire with a pair of wire-cutters until but little of the rivet projects beyond the gold plate, the ends of the pins are spread with the riveting hammer until they fill the countersunk holes in the small metallic plate, and draw the latter in close contact with the rubber. The edges of the plate should be bevelled, and the rivets smoothed with a fine corundum wheel, followed by the Scotch stone, so that no roughness or projection will remain to annoy or abrade the tongue. Fractures of plates at such points is usually guarded against at the time the denture is constructed, by imbedding a semilunar section of the perforated aluminum plate of Wunsche in the rubber while packing in case.

Another method, particularly applicable to plates which are broken entirely in two, consists in adjusting the two parts of the plate together, and fastening them in correct relation to each other temporarily by adhesive wax and shellac dropped on the lingual surface until plaster can be run into the palatal portion of the denture. As soon as the plaster hardens the plate is removed from the model, the line of division enlarged with the file, and dovetails cut opposite each other with a jeweller's saw, as shown by Fig. 623. The dovetailed space is then filled with wax, invested in the usual way in a flask, packed, and vulcanized. This method is open to one serious objection: it necessitates another vulcanizing and the consequent loss of elasticity and toughness; a plate so treated will never be as strong as it was before. Or the edges may be adjusted as before described, and the piece placed immediately in the lower half of the flask: after the plaster has set the adhesive wax is to be removed from the lingual side of the plate, and a line cut with a round engine bur along to the full extent of the crack or break, halfway through

FIG. 623.



the plate and a quarter of an inch wide, with smooth, regular edges, without dovetails. The case is then waxed up and the other half of the flask poured: when the piece is ready for packing the surface of the break is coated with a thick solution of rubber in naphtha; the case is then packed and vulcanized. If the parts have been kept perfectly clean, the union will be quite strong.

To avoid loss of strength by the second vulcanizing it has been recommended that fusible metal, melting at 150° F. or 160° F., be used to fill the dovetailed space. This can be done by pouring the melted alloy into the space and packing it with a hot spatula, which is readily admissible owing to the low fusing-point of the metal. While this method has the advantage of not requiring a second vulcanizing, the union of the metal at the point of fracture is not as close as when rubber is used, and it cannot be said to be reliable as a means of repairing broken rubber plates.

Much the better way is to fasten the parts together, run a plaster model into the denture, then make a bite of plaster to serve as a guide for the replacement of the teeth, remove the latter from the broken plate, reset them to the model, wax up the piece, flask, and vulcanize. This affords practically a new case, and the time consumed is not much greater than is required in repairing the old one.

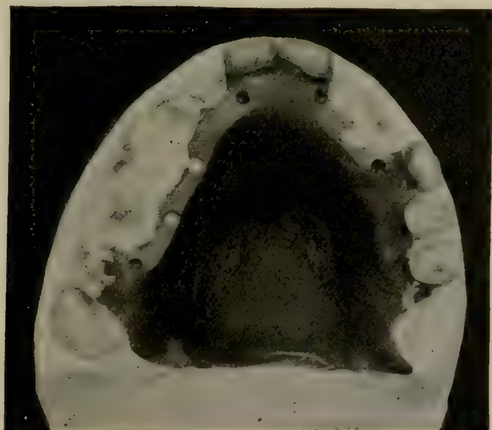
Fig. 624.

Another method for hastily mending broken rubber dentures is as follows: After adjusting the broken parts and making the model for the palatal side, cut through half the depth of the plate from end to end of the break for an eighth of an inch in width on each side of the crack: undercut the edges, drill several holes through the plate, countersinking them on the palatal side. Cut a piece of Wunsche's perforated metal the desired size, press it flat into the groove, and pour fusible metal over it until level with the surface of the plate; when cool dress down and finish. A neat and comparatively secure mend may be secured in this way. Fig. 625 shows a finished piece.

Additions of teeth to old plates are accomplished after practically the same methods. Fig. 625 shows a case where six teeth had been extracted, and the old plate is prepared for the addition of as many porcelain teeth, so that the denture could be worn until the absorption of the alveoli and gums would admit of the construction of a permanent plate. The illustration shows the plate bevelled off to a smooth edge, and several holes drilled into the filed portion. The correct occlusion of the new teeth is obtained by placing the plate in the mouth after the bleeding ceases, and placing two pieces of softened wax along the alveolar ridge and plate, and directing the patient to bite into the wax, and then gently pressing the wax while the teeth are in contact: this gives the correct relation of the lower to the upper teeth, and the impression of that portion of the alveolar ridge to be covered by the addition to the plate. The preparation of the plaster model and bite is done in the usual way, plain teeth being ground to the gums to allow for the rapid absorption which

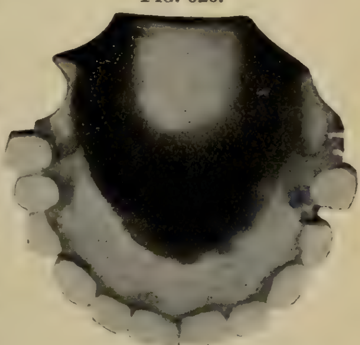
always follows the extraction of teeth. The waxing and flasking are done in the usual way. The filed surface of the plate is then to be coated

FIG. 625.



with rubber solution, packed, vulcanized, and finished. Fig. 626 shows the completed case, the faint lines indicating the point of union of the old and new rubber.

FIG. 626.



Combination Dentures.—Under this heading are included metal plates with vulcanite attachments, vulcanite plates with metal linings, vulcanite dentures strengthened with perforated metal plates, vulcanite in combination with the continuous-gum method, etc. Excellent results may be obtained by attaching the teeth to metallic plates by means of vulcanized rubber. A denture so constructed will be found to possess greater strength than one of vulcanite alone, while it will have the additional advantage of being free from interstices, which favor the lodgement of decomposable débris. In other words, the combination of metal plate with vulcanite attachment thoroughly meets the objections raised against either method alone.

Either gold, silver, platinum, aluminum, or any of their alloys usually employed in prosthetic dentistry may be used in the construction of one of these combination dentures; preference, however, should be given to gold as a base. Platinum unalloyed is not well adapted for the purpose, on account of its great ductility and weight, but when alloyed with a small percentage of iridium its rigidity is so much increased that a plate of No. 29 thickness will be found to be quite as strong as a much thicker plate of 18-carat gold.

Either ordinary silver plate of standard[1] fineness may be used with

[1] Coin.

rubber attachment, or silver alloyed with platinum, the latter having greater tensile strength than the former. It must be remembered, however, that silver has a powerful affinity for sulphur, the indurating agent in vulcanite, and that the presence of platinum as an alloy does not entirely protect the silver from the action of the sulphur. It is therefore necessary, where a silver plate is used, to interpose a layer of No. 60 tin-foil between the rubber and the plate; this precaution, however, is not necessary where celluloid is used.

In silver dentures with vulcanite attachments the anchorages must invariably be made of platinum or gold wire. After the plaster wall is made and the wax removed from around the teeth, the exact positions of the anchorages are marked upon the plate with a sharp steel point to the number of eight or ten. The plate is then laid on a charcoal support, and pieces of silver solder are fused at the points indicated. The wire is then cut into proper lengths, screwed in a vise, and one end of each flattened by means of a rivetting hammer into the form of a head: each pin is then taken up separately, the headed end dipped in borax, and placed on the plate at a point where a piece of solder has been fused. The borax will assist in retaining the piece of wire until the flame of the blowpipe is directed upon it to remelt the solder and unite the pin to the plate. The wire anchorages are not to be bent into hook form, as shown in Fig. 629, until after the tin-foil protection has been adjusted. The pins are forced through the tin-foil and pressed with a rubber point, and burnished closely to the plate. The holes made by the passage of the pins through the tin-foil, if care is used, will not be large enough to allow the rubber to reach the silver to any great extent. After the tin is in place the pins may be bent with pliers, as shown in Fig. 629.

Another method is by directly tinning the surface to be covered by the rubber. The silver is cleansed and covered with a saturated solution of zinc chloride. The tin-foil is pressed carefully against the silver and the plate is held above a Bunsen flame until the tin fuses. Its flowing is to be directed by means of a camel's-hair pencil which has been dipped in the zinc solution.

Vulcanite in Combination with Plates of Fusible Alloy.—For the modus operandi in the preparation of plates of fusible alloys the reader is referred to Chapter XIV. Figs. 551 and 552 satisfactorily illustrate upper and lower fusible metal plates prepared for vulcanite attachments. The Reese or Weston fusible alloys can be cast very thin, and yet be sufficiently rigid to withstand the force of mastication. These alloys retain their color and make an admirable combination plate. Having finished the plates as shown above, the edges and raised rims are trimmed to the desired dimensions. A roll of softened gutta-percha or wax is pressed around the gums over the alveolar ridges, and trimmed with a knife to the supposed height of the teeth. The plates are then tried in the mouth, and the wax trimmed from all sides until perfect occlusion and contour are obtained. The median line is marked on the gutta-percha or wax, as the case may be, and the cutting edges marked in several places to serve as guides in restoring the upper and lower waxes to their correct relation to each other should they become separated. The articulating models are prepared in the usual way—pouring plaster into the lower plate, first allowing it to extend back sufficiently to

receive the upper half, which is to be poured next. The gutta-percha is then to be removed and the teeth arranged and waxed up and vulcanized. The attachment of the vulcanite to the plate may be secured by freely nicking the ridge to which the teeth are to be fastened by means of a sharp-pointed graver, but without this the undercut of the rims and buttons will be ample to hold the vulcanite securely to the metal.

Aluminum, though not affected by sulphur, is not as well suited for vulcanite attachments as the other metals named, on account of the want of reliable aluminum solder with which to fasten the loops or pins thoroughly; but by special treatment, which will be described in connection with the manner of preparing aluminum plates, a comparatively durable denture can be made of that metal with vulcanite.

In constructing a denture of gold with vulcanite attachments the plate should be of the thickness of No. 27 of the standard gauge, and made in accordance with the directions for the making of gold and silver plates in Chapter IX.

It should be provided with a rim extending entirely around the labial and buccal edges and upon the palatal portion of the plate slightly posterior to the alveolar ridge, as shown by A and B, in Fig. 627. This rim

Fig. 627.

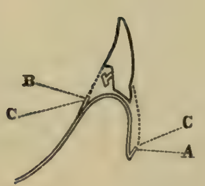
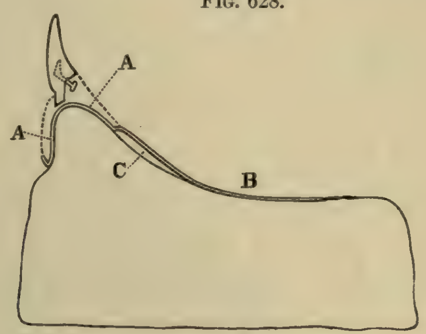


Fig. 628.



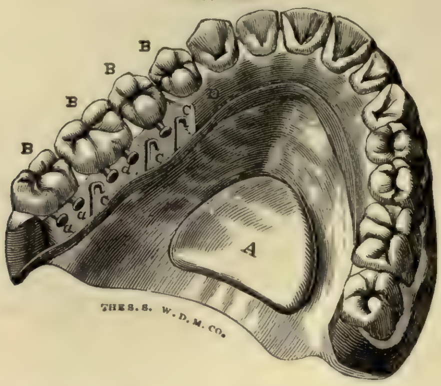
may be soldered, or swaged as shown by Fig. 628. If soldered, it may be formed of No. 27 plate or round wire of No. 17 gauge. A rim formed of round or triangular wire requires much less labor and time in its adjustment than if formed of a strip of plate, and when flattened with the file on the labial side, and the corundum wheel and graver on the palatal side, it has the same effect as if it was formed of plate.

The rim may be dispensed with entirely, but, as it gives a more finished appearance to the denture and adds greatly to its strength, it should therefore always be preferred.

In attaching a flat rim to a gold or silver plate a strip of plate long enough to extend entirely around the rubber attachment should be cut, as shown by Fig. 632. The rim should be annealed, and bent with the pliers to fit the labial and buccal edges on the plate. It is then placed on a charcoal support, and the rim held in contact with the plate by means of small nails or tacks: it is then united to the plate by a small piece of solder immediately in front at the frænum and at one or two other points along the buccal edges. The plate is then

cooled, placed upon the plaster model, and with a small hammer and pliers the rim is brought in close enough contact with the plate to

Fig. 629.



admit of complete soldering. The palatal portion of the rim should not be soldered to the plate until after the correct position of the teeth has been ascertained. This is accomplished by arranging the teeth according to the bite and other requirements of the case, and then making a wall of plaster around them, separated at the centre line. This enables the operator to mark upon the plate with a sharp instrument the correct point at which to solder the rim, so that it will leave an unbroken surface for the tongue, as shown by *B* in Fig. 627, and to mark the proper position for the loops or bent-pin attachments, as shown by *A* in Fig. 628. It is very important that the exact location of these fastenings should be ascertained, but this cannot be determined until after the teeth have been adjusted. Any attempt to solder the rim or fastenings previous to the fitting and arrangement of the teeth will be but guesswork, and nearly always results in either of the conditions shown in Figs. 630 and 631.

Fig. 630.

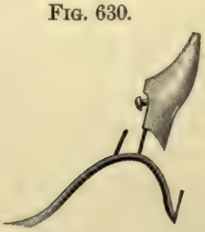


Fig. 631.

The wire rim is soldered to its place by simply clamping the wire to the plate, and then attaching it at single points in front and at the buccal edges, and, after the correct position of the teeth has been ascertained, bringing it entirely around at the palatal portion, as shown by *C* in Fig. 629. By simple pressure with an instrument or gently tapping with a riveting hammer it may be brought into close contact with the plate and completely soldered. It need not be flattened and finished until after the case is vulcanized.

In soldering the flat or plate rim it is necessary to hold the rim in contact with the plate for the preliminary attachment; care must be

FIG. 632.

FIG. 633.

exercised to avoid springing or warping the plate. The small nails or

carpet tacks used to hold the rim to the plate should be fixed at points shown in Fig. 632, and never on each side of the plate, as shown by Fig. 633. The greatest expansion occurs across the broadest part of the plate, and if it is confined at that point, and then heated to redness, it will invariably be found warped to such an extent that its adaptation to the model will be impaired.

Instead of an inside rim, some mechanical dentists prefer to form the air-chamber in the shape of a horseshoe, as shown in Fig. 634.

FIG. 634.

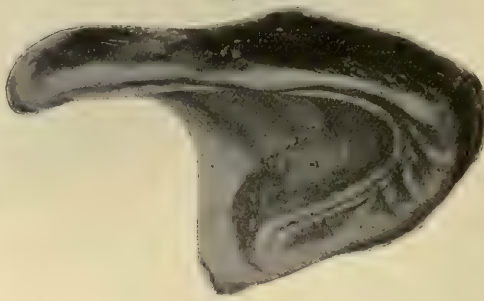
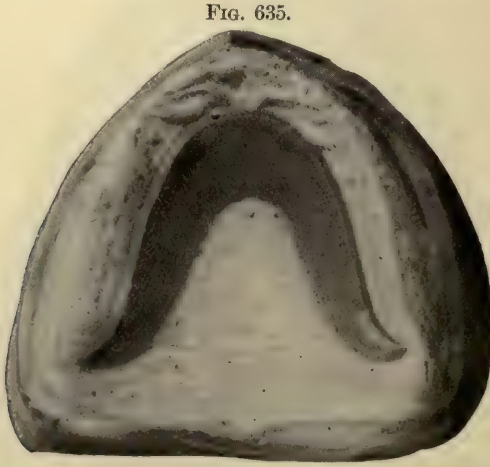


Fig. 628 gives a sectional view of the arrangement. *AA* represents the vulcanite attachment, *B* the metal plate, *C* the air-chamber blending at its lower edge with the plate and at its upper with the vulcanite, leaving an unbroken surface for the tongue. This form of air-chamber is well adapted to swaged aluminum plates designed for vulcanite attachments. With the outer rim also turned up in the swaging, it affords nearly the same effect as the soldered continuous rim above described. Fig. 635 shows a plaster model with wax arranged previous

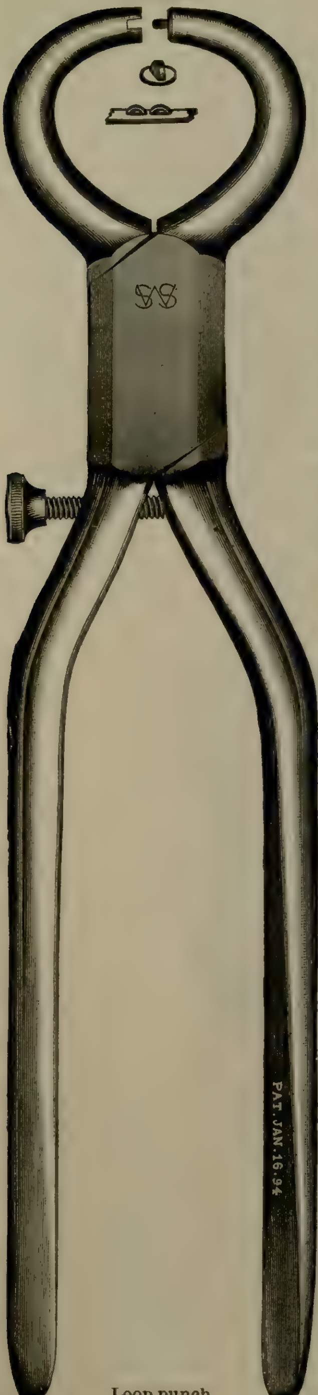
FIG. 635.



to the making of dies and counter-dies, so that chamber and rim may be swaged from one piece of metal.

Owing to the difficulty in soldering aluminum, it is necessary to secure attachment for the vulcanite to the plate by means of perforations

Fig. 636.



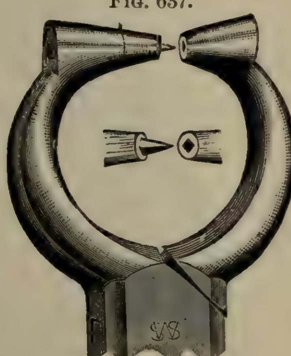
Loop punch.

or countersunk holes along the top of the ridge. For this purpose ingenious perforating punches have been devised by Drs. Richmond and Peck, as shown by Figs. 636 and 637, the latter throwing up a sharp square bur, the other a loop. The punch points entering from the under side of the plate produce the desired result without in the least bending or affecting the fit of the plate.

A rolled aluminum plate, constructed in the manner shown by Fig. 634 and roughened by means of the punches (Figs. 636 or 637), and with the teeth attached by means of vulcanite, will afford a light, strong, and comparatively durable denture.

Dr. J. W. Hollingsworth[1] of Green Castle, Indiana, describes a method of preparing aluminum plates for vulcanite attachments, as follows: "Perforate the ridge of the plate at proper points and intervals; then pass through these perforations, from the inner surface of the plate, headed pins made of aluminum, which, after replacing

Fig. 637.



Perforating forceps No. 9.

Fig. 638.

[1] Richardson's *Mechanical Dentistry.*

the plate with the pins back upon the die, are shrunken down to permanency with a hollow punch. The punch must be made with the hole not quite equal in depth to the length of the extruding portion of the pins and slightly bell-mouthed. The riveting process forms seriate studs or pins, which may be bent or flattened with pliers in any way to suit the requirements of the case."

Continuous-gum and Vulcanite Combination.—A continuous-gum front is made on a platinum plate of the usual thickness (No. 29), of sufficient width to fit the alveolar ridge, extending back of the ridge far enough to admit of the edge of the plate being turned up sufficiently to engage the vulcanite palatal portion of the plate. This turned edge is perforated at close intervals with the plate-punch, so that the union of the vulcanite with the plate may be strong. On the labial and buccal surfaces the platinum plate should reach as high as the porcelain is to extend. The plate is to be made in the manner usual in continuous-gum work, with swaged rim, etc., the only difference being that a stout platinum wire is soldered across from one extremity of the plate to the other to prevent warping during exposure to the high temperature of the furnace: this wire is to be removed when the piece is ready for the vulcanite palatal portion. (See Fig. 639.)

Fig. 639.

Showing platinum wire support.

The fitting and soldering of the teeth and the application and fusing of the porcelain body and enamel are to be done as described in the chapter on the Continuous-gum Process. The ductility of platinum is greatly increased by high temperature: it is therefore necessary that all parts of the plate should be well supported during the fusing of the body and enamel. This may be accomplished by placing it upon a bed of coarse silex and carefully building the silex up to and under the plate, so that no part of it can sag when exposed to the fusing-point of the body. After the several burnings are complete, the plate is placed on the plaster model and the portion to be formed of vulcanite represented in wax, flasked, packed, vulcanized, and finished.

This is the only practical method of combining vulcanite with con-

tinuous gum. It has, however, not found much favor with dental prosthetists for obvious reasons.

Vulcanite is of great value in refitting gold plates which have ceased to fit the mouth in consequence of changes by absorption following the extraction of the teeth. These changes may continue in some cases for several years after the removal of the natural organs, to such an extent finally that the denture will no longer be of service. The absorption usually occurs along the alveolar ridge, and it is a matter requiring but little time or labor to adjust the denture to a new plaster model, fill the spaces caused by absorption with wax, invest, pack, and vulcanize the piece. Care must be observed to make countersunk perforations through the plate at points where the vulcanite is to be attached, so as to secure firm union with the gold plate.

Vulcanite Plates lined with Gold-foil, Electro-deposits, etc.—Various experiments have been made with this class of work in the last twenty-five years, with a view to developing some process by which a durable metallic coating can be given to that portion of the vulcanite denture which is in contact with the alveolar and palatal portion of the mouth. There are two methods: one consists in coating the surface of the plaster model with gold by electro-deposition, by first rendering it impervious to warm water, so that it will not take up and destroy the gold bath. The surface to be electro-plated must be hard and smooth and free from

FIG. 640.

The vulcan gold lining.

all greasy substances. It must be thoroughly coated with plumbago and painted with a solution of chloride of gold to facilitate rapid deposition over the whole surface.

The next and simplest form is to coat sheets of No. 8 or 10 gold-foil with a non-conductor on one side, or by putting two sheets together with a non-conductor—as wax, for instance—between them, and sealing the edges with wax to prevent the gold solution from penetrating between or through the sheets. A rough granular coating of gold or copper can be deposited on the exposed sides, which will ensure comparatively good adhesion with the plate after vulcanizing.

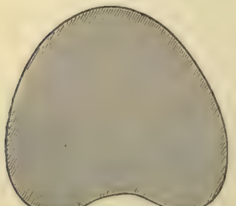
Another method is what is known as the "Vulcan gold lining." It is a pure gold sheet covered on one side with a thin coating of silver (Fig. 640). The gold is applied in one piece to the surface to be covered, and no extra care is required in packing the flask. The lining is of chemically pure gold on one side with a thin covering of pure silver on the other. The union between the rubber plate and the gold lining is mechanical: the sulphur in the rubber acting upon the surface of the silver produces a condition of surface which favors adhesion.

This foil is of the thickness of No. 40. In applying it, the case should be packed first; the flask is then separated, and any imperfections in the model are to be repaired with thin plaster or oxyphosphate cement. The model is then to be painted with a thin solution of equal parts of shellac and sandarac dissolved in alcohol. When dry, coat the surface with dextrin, gum tragacanth, or damar varnish, and while still moist and sticky press small pieces of the gold lining on to the model, bright side down. The gold lining is first cut into convenient strips of the form of oblongs, squares, and triangles, to avoid wrinkling. The edges should slightly overlap, and the lining be kept free from varnish or any substance that would be likely to interfere with adhesion. Pressure on the granular side of the foil with a steel instrument should also be avoided. The rubber end of a lead pencil or the finger is the best means of pressing the gold into all the irregularities of the model. The flask should then be carefully closed and the piece vulcanized.

Dr. Joseph Speyer has introduced a method of lining vulcanite and celluloid dentures consisting of a thin metallic plate of the thickness of No. 120 foil, the surface of which is covered with minute papilliform prominences (shown in Fig. 645, magnified four diameters), which are claimed to effect very strong surface cohesion, while they cause no irritation and leave no marked indentations on the tissues. The forms illustrated by Fig. 644 are made of gold with one side covered with a thin layer of silver. In vulcanizing the surface of the silver is corroded by the sulphur, causing it to adhere to the vulcanite with great tenacity.

Speyer's Adhesive Plate.—Another device of the same inventor consists of a layer of an unvulcanizable rubber plate which is attached

FIG. 641.

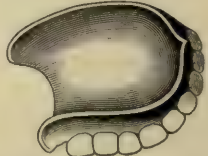


Showing Speyer's adhesive plate for upper dentures.

FIG. 642.

Showing the adhesive plate for lower dentures.

FIG. 643.



Showing finished denture.

to the palatal surface of vulcanite plates; the preparation of which it is composed yields slightly, and furnishes a firmer adhesion than does the hard, smooth surface of vulcanized rubber (Figs. 641, 642, 643).

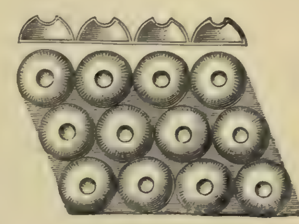
After the wax is boiled out and the case packed, the flask closed, then reopened, the adhesive plate is trimmed so as to cover the entire palatal

surface of the rubber. It is then softened by dipping it in warm water, laid on the rubber, tin-foil side up, and the flask closed. In vulcanizing the adhesive plate incorporates with the rubber, and will be found to cover the entire interior surface of the plate on the palatal side. After vulcanizing the tin-foil is removed.

The adhesive plate can be vulcanized to the palatal surface of old plates, producing strong adhesion and obviating the necessity of making a new plate.

Fig. 644.

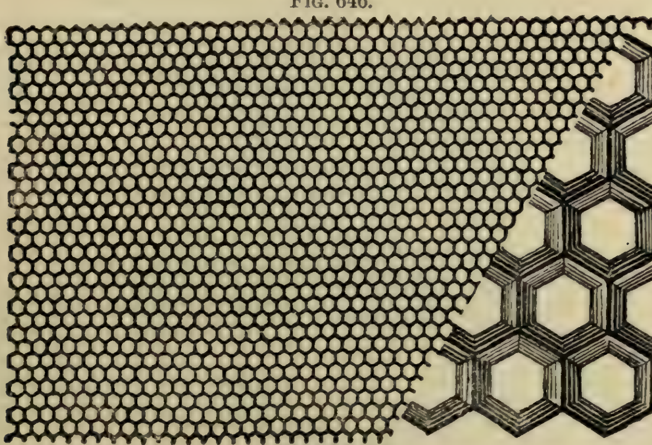
Fig. 645.



Surface-cohesion forms for artificial dentures.

Combination of Vulcanite with Perforated Plates.—Gold and platinum gauze has been used as a means of strengthening vulcanite dentures as long ago as 1865. Dr. Robert Wunsche of Germany has

Fig. 646.



Combination dentures.

devised a perforated plate which has found favor with many of the most skilful prosthetists in this country and abroad. These perforated plates are stamped from gold, aluminum, and Victoria metal, and are very light and strong. Fig. 646 shows one of the perforated plates as

prepared for use. A part of the plate on the right shows the perforations as they appear under a strong magnifier. It will be seen that the holes are countersunk, so that when the rubber is forced through it forms a head or clinch on the face of the plate, making it impossible to detach the plate by any ordinary force. It is claimed that by the use of this plate a lighter, thinner, and stronger plate can be made than by vulcanite alone, and such a combination presents the novel appearance of a reticulate metallic structure with vulcanite filling the coned interstices. It is also thought to be better from a hygienic standpoint for the tongue and mucous membrane, on account of the conducting quality of the metal, than vulcanite alone. Figs. 647 and 648 illustrate two partial dentures made by Dr. Wunsche. Fig. 647 shows the lingual portion

Fig. 647.

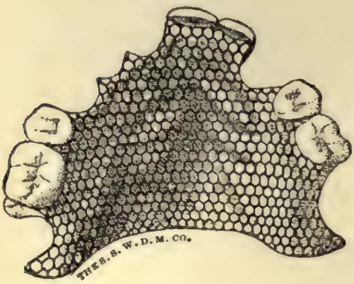
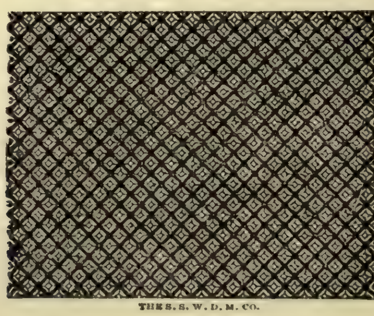


Fig. 648.

of the plate with the reticulate form used. Fig. 649 illustrates another form of perforation, which is diamond-shaped and presents an artistic appearance when finished.

Fig. 649.



In the application of perforated plates it is desirable to obtain two models of the mouth, reserving the best one for vulcanizing on, and utilizing the other in obtaining a zinc die and lead counter-die with which to swage the perforated plate.

Dr. Wunsche gives the following description of his method of applying the perforated plate which bears his name: "The counter-die is best obtained by first burnishing on to model No. 2 a thin tea-lead or pattern-tin plate, over which, after oiling the exposed plaster surface, the thick-mixed plaster can be poured to form the counter-cast. When separated

the tin plate is to be flattened and laid on the combination plate as a pattern for cutting an approximation to the size and shape of the perforated blank. This blank is then heated slightly and carefully when aluminum is used, on account of its low fusing-point, and pressed gently with the fingers on to the No. 2 model, over which a piece of thin, soft, wet muslin has first been laid to keep the plaster out of the perforations, the smaller mouths of which lie next the muslin. Another piece of wet muslin is laid on the plate, and with the counter-model gentle hand-pressure is made to partially conform the plate. This plate is then annealed, put between the wet muslins on the No. 2 model, and, with the counter-die in place, is put under a screw-press and softly pressed to shape. The case is then opened, closely cut to fit margins, annealed, replaced, and tightly pressed into place. Due care and caution should be observed to prevent and overcome any tendency to wrinkle: a smooth, nearly conforming plate may thus be made to fit the deepest vault or most irregular ridge.

If a vacuum chamber is contemplated, provision must be made for it in the plaster model as usual. If the Speyer plate (shown in Fig. 644) is proposed, a suitable piece of the adhesive plate metal must be placed on the No. 2 model, the cup mouths toward the model, and pressed by the counter-die into place, and shaped before proceeding to make the combination plate as previously described.

Model No. 1 having been placed in the articulator after obtaining the bite, a very thin wax plate is put on; the combination plate is warmed and neatly pressed into place, so that the wax will come through the perforations and by nice manipulation be made flush with the metal surface, which must not be covered with the wax.

The flasking and vulcanizing are done as usual, excepting the time of exposure, which is lengthened twenty minutes to make a harder vulcanite, and thus strengthen the reticulate metal, and with it form a combination plate of remarkable strength, stiffness, and artistic appearance. Either pink or black rubber may be used; the latter, however, makes a stronger plate.

For partial dentures having isolated teeth—as two laterals, for example—the perforated metal is of great advantage in strengthening the thin isthmus which connects each artificial lateral tooth with the plate.

In every case the finishing process should remove from the lingual surface only the vulcanite overlapping the metal; the latter should not be scraped, but merely polished with its enclosed vulcanite. When properly modelled in waxing the finishing is but the work of a few minutes, and the resulting light and thin plate will be sufficiently strong and exceedingly artistic in appearance.

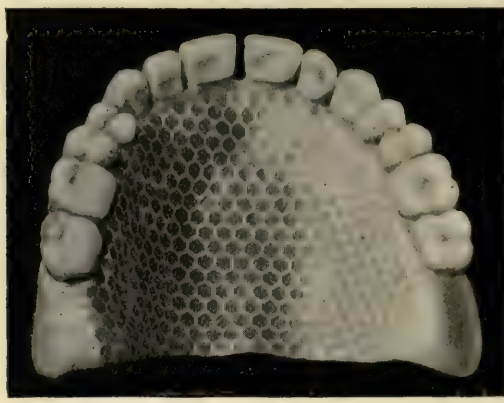
Figs. 650 and 651 show a full upper denture with the metallic network, having the pink rubber between.

Fig. 651 shows a denture with plain teeth, pink rubber in front, gold lined on the palatal side, with a vacuum chamber made with the Speyer-Fenner suction surface of aluminum. By this combination a denture may be constructed possessing lightness, strength, and cleanliness. In the case shown by Fig. 651 the waxing was done with precision, and tin-foil was burnished over the labial portion, so that after vulcanizing it

required no other finishing than the mere use of the brush-wheel in the final polishing.

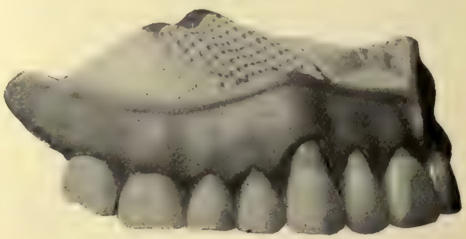
Two comparatively new kinds of rubber have been introduced within

FIG. 650.



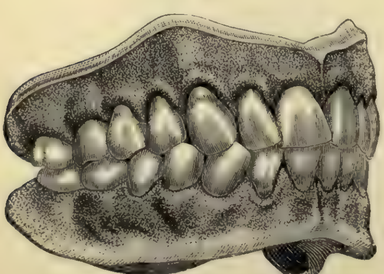
two or three years that commend themselves for use in the combination plate described above. One is the "granular-gum" rubber facing by

FIG. 651.



Dr. Gilbert Walker, in the use of which the following directions are given: "In waxing up a case, carefully model the gum portions to the exact contour desired, and make festoons smooth at the necks of the teeth. After flasking, face with a layer of granular gum cut to lie close around the labial and buccal necks of the teeth, and pack against the outer wall of the plaster investment, so that the facing shall not extend above the edges of the plaster. Lap the pieces of granular gum carefully, so that the red rubber will not be squeezed between them, and show on the facing after vulcanizing. In packing the red rubber care must be taken not to have an excess, else the overflow may carry with it the granular gum and elongate its colored

FIG. 652.



particles, thus interfering with the mosaic appearance on which the imitation of the gum depends.

The palatal part of the plate may likewise be faced, with care in lapping the pieces of granular gum and avoiding an overplus of red rubber. With this form of rubber exposure to sunlight for the purpose of developing its color is unnecessary; when well polished the moisture of the mouth will improve the tint.

Granular gum vulcanizes with any of the ordinary rubbers; better results are, however, obtained by vulcanizing it at a low temperature. In finishing care should be exercised to avoid cutting through the thin facing.

Gear's shaded pink rubber is somewhat similar to the granular gum described above. It may be used in the same manner as the latter, and adds greatly to the beauty and natural appearance of the gum portion of the denture if the preliminary modelling has been done with taste and skill.

Beaded or Grooved Vulcanite Dentures.—For the more complete exclusion of air and moisture from between the artificial denture and the mucous membrane upon which it rests a groove is cut in the plaster model, as shown in Fig. 653,[1] so that the vulcanized denture should have an integral half-round smooth bead formed on its vault aspect, as in Fig. 654.[2] The groove must be carried continuously across the palatal portion of the plaster model and along the buccal and labial lines of muscle attachments, to form a bead-enclosure which should produce a supplemental chamber-like function of the entire inner surface of the denture (Figs. 653 and 654).

FIG. 653.

This bead is of especial value in cases where no chamber is used, and in connection with the chamber it greatly increases the amount of atmospheric adhesion.

It may be applied to partial dentures, as shown in Fig. 655.[3] Care must be observed in removing the denture from the flask and in freeing it from the plaster, that the bead is not accidentally damaged or cut through at one or more points by the plaster-knife. The groove may

[1] *Dental Cosmos*, July, 1895, p. 582. [2] *Ibid.* [3] *Ibid.*

be conveniently scraped on the plaster model by one of the larger-sized Palmer's excavators, which, being rounded at its cutting edge, will afford a half-round bead in the vulcanized piece.

Plates made from wax impressions and those which have become slightly warped in polishing, or where the gum in consequence of

FIG. 654.

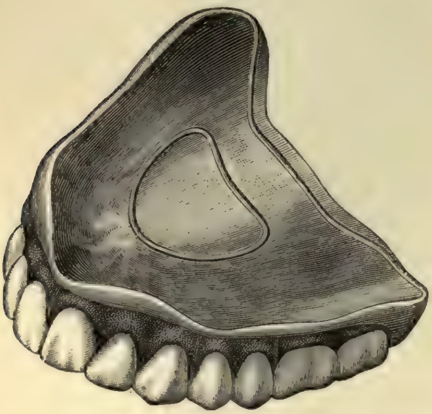
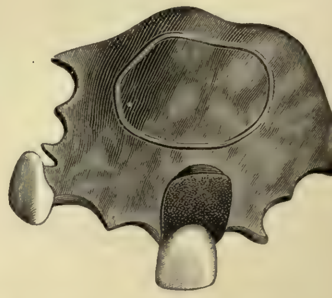


FIG. 655.



absorption following the loss of teeth shrinks away from the plate, may need slight bending to secure closer contact with the palatal portion of the mouth. This may be safely accomplished by oiling the palatal surface of the plate and running plaster into it to form a model. When hard the plate is to be removed and the plaster model scraped away to an extent corresponding with the amount of change required to bring the edge of the plate in close contact with the tissues. The plate is then to be coated with olive oil to prevent burning, heated over a spirit lamp, and when sufficiently pliable placed upon the model, previously warmed, and, with a piece of chamois skin laid over the portion to be bent, press it home with the finger, a tooth-brush handle, or a large ball burnisher, and hold firmly until cold.

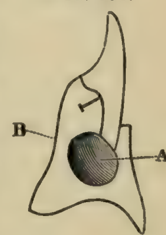
Weighted Vulcanite Dentures and Dentures with Plumpers.—As a rule, lower dentures formed of vulcanite have not sufficient weight to overcome the resistance of the muscles of the cheeks and the sublingual integuments, and when the bite is unusually short they are also deficient in strength, so that breakage of lower dentures is a common occurrence. Both of these defects may be remedied by constructing a platinum or gold plate of two thicknesses of No. 29, soldering suitable anchorages near the top of the ridge in a position which will not interfere with the teeth, and vulcanize as described under the heading of Combination Dentures.

A less expensive method of adding weight to a vulcanite denture consists in using rubber, which is prepared for the purpose with tin filings incorporated in it. By this means the requirements as to weight are very nearly fulfilled, but no additional strength is acquired, the only means of overcoming that difficulty being the use of a metallic plate.

When the bite is unusually long it may be waxed and flasked in the usual manner, and after the flask has been separated preparatory to pack-

ing a cylindrical rod of wax may be laid upon the under sides of the blocks or single teeth, as the case may be, of sufficient length to extend from one finishing molar to the other. The wax rod is then carefully lifted from its place and invested in plaster to form a mould which should be in two equal halves, the line of division being exactly in the centre of the diameter of the wax rod. This mould should have a gate bored through the top for convenience in pouring melted tin, while at the other extremity it should be provided with a vent to allow of the escape of air at the instant of pouring the melted tin. The tin may be melted in a small iron ladle with a suitable handle, and the melting may easily be accomplished over a gas-jet or alcohol flame. When the casting is complete and the tin sufficiently cool, the mould may be opened and the tin facsimile of the wax rod placed in position in the flask, resting upon the teeth, as previously indicated in the description of the preparation of the wax pattern rod. The tin rod should be so arranged that all parts of it will be covered by the vulcanite. Fig. 656 shows the arrangement as described, *A* indicating the tin, *B* the vulcanite. This method possesses the additional advantage of preventing porosity of the vulcanite—an accident which is very liable to occur in bulky lower dentures.

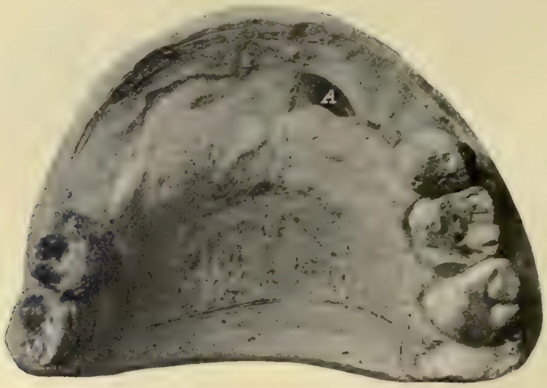
Fig. 656.



It is sometimes necessary to amplify the denture at points where unnatural depression occurs in consequence of great absorption following the loss of cuspids or molars. If the amount of projection required to restore natural expression is not extraordinary, slight additions to the rim and the usual vulcanizing may be relied upon to accomplish the desired result; but if the case require a large mass, exceeding a quarter of an inch in thickness, the vulcanizing must be done at a lower temperature, of, say, 300° F., and three hours' exposure in the vulcanizer, in order to avoid porosity. Equally good results may also be attained by forming a core of some light material, enveloping it in rubber, and with it filling the recess in the flask representing the "plumper." For this purpose cores of thin metal hermetically sealed, approximating the form of the plumper and one-eighth of an inch smaller than the latter may be used. The preparation of metallic forms is, however, a matter requiring considerable labor and time. A much simpler and equally effective method is to form a core either of vulcanized rubber sponge or cotton wool tightly rolled and wrapped with thread. In packing the core is not to be placed in position until the case has been packed and the flask completely brought together, when it may be opened, the recesses representing the plumpers freed from rubber, and the cores, previously wrapped with strips of soft rubber to the thickness of an eighth of an inch, put in its place. The object of first packing and closing the flask is to prevent the flow of rubber from displacing the cores and to ensure their complete envelopment. In finishing such a case care must be exercised to avoid cutting through the rubber and exposing the sponge or cotton when those materials are used. Probably of the materials named a piece of hard vulcanite affords the best results and is less likely to lead to failure through displacement, which is always liable to occur.

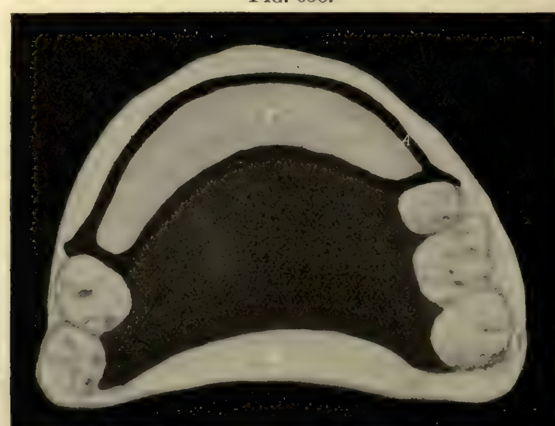
The same course as outlined above in the preparation of ordinary plumpers may be pursued in making plates to restore contours when large portions of the maxillary bones have been lost by disease or accident, such as gunshot wounds, etc. Fig. 657 shows a model of the

Fig. 657.



mouth of a syphilitic subject in which the whole anterior portion of the alveolar ridge had been removed, leaving a large opening, *A*, into the nasal cavity, by which speech was seriously affected. After obtaining the model a thin plate of wax was prepared to cover the palatal portion (as shown in Fig. 658) extending around the teeth in the form of half clasps, and through the opening *A* in Fig. 657 even with the floor of the nasal cavity. A narrow strip of wax was then built around the

Fig. 658.



labial edge *A* (Fig. 658), and another around the palatal border of the ridge, as shown by *B*. After smoothing down and blending the wax with the palatal portion of the plate by means of a hot spatula, a hollow space, *C*, remained at the point where the alveolar ridge had been removed during surgical treatment. The wax plate thus prepared was

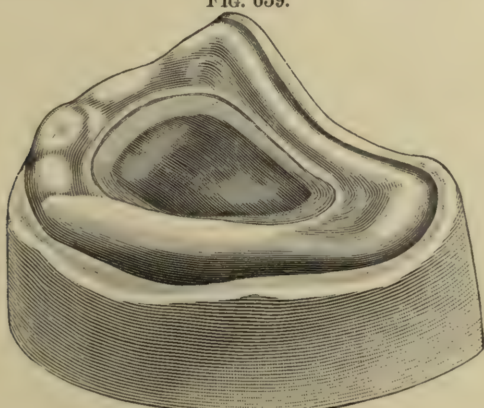
invested in an ordinary flask and vulcanized in black rubber, as shown in Fig. 658. When finished the hollow space *C* was filled in with a mixture of sand and plaster to form a core, and dressed to the inner edges of *A* and *B* (Fig. 658) to represent the lost portion of the alveolar ridge. Placing the plate in the mouth with some softened wax along the ridge, the patient was requested to bite into it, thus forming the occlusion. After pouring the under side of the plate the articulating model was made as usual. The teeth were fitted and arranged, and waxed to the outer edges of *A* and *B* projections. The case was then flasked and vulcanized in the usual way. When entirely finished a hole was drilled through the projection which filled the opening to the nasal cavity, and another through the end resting against the right molar: through these openings the core of sand and plaster was removed by means of a wire; when quite empty the openings were securely sealed. Speech was entirely restored by the fixture, which was light and strong and did good service for many years.

Vulcanite dentures are occasionally retained *in situ* by means of spiral springs. This method of retention is, however, but seldom resorted to, except in cases of extreme flatness of the mouth or else in the correction of oral deformities. (For a description of the preparation and adjustment of spiral springs the reader is referred to Chapter XIII.)

Vulcanite Plates with Flexible Rubber Rims.—The use of flexible rubbers in connection with artificial dentures is of doubtful value, on account of the inevitable loss of flexibility of all semi-vulcanizable rubbers when worn in the mouth. The term of durability of a flexible rim is but a few months, but its advocates claim that its object will have been attained by that time, and that the patient will have acquired the ability to retain the plate without it.

In the construction of such a plate a line should be carefully made

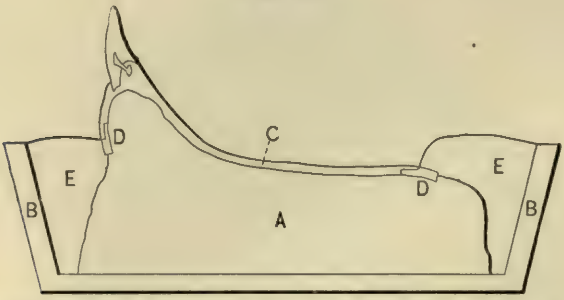
FIG. 659.



on the model entirely around the outside of the alveolar ridge and across the posterior border of the hard palate. The line should not be carried too high at the point occupied by the buccinator muscles, and it should indicate the extent of the outer edge of the plate when finished; it must be sunk to the depth of a thirty-second of an inch all around, and tapered to the width of an eighth of an inch, blending with the model

at the inner margin (Fig. 659). In this groove two thicknesses of velum rubber, which can be obtained from any dental dépôt, should be laid. The rubber may be made to adhere to the model by first coating the latter with a solution of the rubber dissolved in chloroform, which will retain it in position while waxing up (Fig. 660). The model is

FIG. 660.



then to be covered with a thin plate of paraffin and wax, allowing it to extend over the flexible rubber rim one half. The wax is to be trimmed carefully, so that the edge will be sharp and clearly defined, and care should be observed that no melted wax is allowed to touch the outer portion of the flexible rim, as its flexibility would be impaired by combination with wax. The teeth are mounted and flasked in the manner already described, except that it is necessary to cover the exposed rim of flexible rubber with a good body of plaster to ensure its retention in position. (See sectional cut, Fig. 660, *A* representing the model; *B*, *B*, the flask; *C* the hard vulcanite plate, and showing the dovetail joint with *D*, *D*, the flexible rubber rim; *E*, *E*, the plaster investment securely holding it in position during packing and vulcanizing.) It is essential to have a solid body of plaster over the soft rim to prevent the hard rubber from finding its way in and affecting its flexibility. The finishing of the plate after vulcanizing is the same as heretofore given. The necessity for care in the arrangement of the flexible rim to the model becomes apparent. Since it is not possible to trim and polish rubbers of that class after vulcanizing, their condition of surface will depend upon the state of the matrix in which they are moulded.

Pink Vulcanite in Combination with Soldered Dentures.—One of the most important applications of vulcanizable rubbers is its combination with plain teeth, where it is often employed to form the rim and gums and to supply at appropriate points sufficient bulk (plumpers) to restore the natural contour of the face.

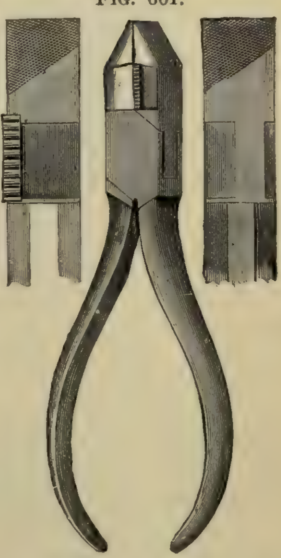
When used to form the gums in connection with plain teeth it affords a denture possessing distinct advantages over one formed of single gum teeth, in that the teeth are strengthened by the pink vulcanite, and all spaces and interspaces favorable to the lodgement of food-débris are completely filled by the vulcanite, thereby rendering the denture clean and much more agreeable to the wearer.

The plan of procedure is to mount the plain teeth on a gold or platinum plate, back, solder, and finish them. Wax is then built on the plate from the labial and buccal edges to the necks of the plain teeth,

and carefully modelled to imitate irregularities of the natural gums. It is then to be invested in the first half of a vulcanite flask, with the cutting edges of the teeth downward, the plaster being allowed to cover the entire plate, the only part of the denture exposed being the wax at the rim edge of the plate; and only enough of the wax at that point need be exposed to allow access in packing the rubber around the teeth. The second half of the flask is then adjusted and filled with plaster when the flasking is complete: after the flask is opened and the wax removed by washing out with a stream of boiling water, the pink rubber is cut into narrow strips, softened by gentle heat, and carefully packed into the vacancy left by the wax. This packing must be done with the utmost care, in order that all spaces may be thoroughly filled with rubber. When quite full a slight excess of rubber should be added to ensure sufficient pressure to thoroughly distribute the rubber. It may then be vulcanized and finished, as described in another part of this chapter. Ordinary pink vulcanite requires exposure in alcohol to solar rays to fully develop the pink tint. The Walker granular gum, which is stronger than the ordinary pink rubber, may be employed.

Vulcanite Regulating Appliances.—Although the vulcanite regulating plate has to a great extent given place to appliances constructed of metal after the Farrar, Angle and Patrick systems, yet cases will constantly arise where fixtures constructed of vulcanite alone or in combination with gold will be found to be almost indispensable in the treatment and retention of irregularities of the teeth. It would be impossible to give in these pages a complete classification of the almost limitless variety of regulating appliances formed of vulcanite. A few models have therefore been selected to represent some of the most practical and useful forms. Figs. 211, 212 and 213 are typical regulating plates of the system devised for the upper and lower jaws by Walter H. Coffin, F. C. S., F. R. M. S., M. Phys. S. of London, England. The wire in Fig. 213 shows the form best adapted for expanding the anterior portion of the arch; that in Fig. 211, the form adapted to enlarging the posterior portion. The additional wire on the left of Fig. 211 is intended to force a lateral incisor outward, while the W-shaped piece expands the arch to allow room for the lateral to assume its proper place in relation to the neighboring teeth. It is assumed in this system of regulating that all irregularities of the teeth require for their correction the spreading of the arch, and it is for this purpose that the split plate and piano wire in the shape shown in the figure are used, and individual teeth to be moved or rotated are acted upon by other wires fastened in the plate in such positions as may be required.[1] "The effectiveness of the

FIG. 661.



[1] From Dr. H. J. McKellop's paper, published in vol. xxiv. pp. 477–479 of *Dental Cosmos.*

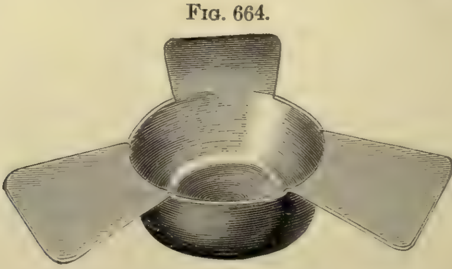
Coffin appliance depends upon the elasticity of a piece of piano wire, and if all the details of the construction and application of an appliance after the Coffin method have been carefully executed, the patient may be safely entrusted with its subsequent management. The impression in this, as in the preparation of all other forms of regulating apparatus, should be taken in plaster. The length of wire required is from 1 inch to $3\frac{1}{2}$ inches in ordinary cases. In the construction of the Coffin apparatus two pairs of pliers and a pair of clasp-benders are used (Figs. 661 to 663). The jaws of the largest of the

FIG. 662.

FIG. 663.

pliers (Fig. 661) are provided with a wire-cutting side for cutting the wire into the proper length and also to bend it to the required shape. After the wire is cut off with the large pliers it is bent first in the centre, then back on each side with the clasp-benders (Fig. 663), holding it with the pliers. Care must be taken to avoid getting any twists in

FIG. 664.



the wire and to make the curves smooth and even. It is then put into shape to occupy its proper place when attached to the plate by adjusting it with the fingers and the pliers, after which the ends to be secured in

the rubber are bent at a sharp angle, so as to raise the part which projects from the plate, and flattened with a hammer: no part of the wire should be heated. The appearance of a wire ready for use is shown in Fig. 210. The ends of the wire are then tinned, a small copper cup filled with molten tin (Fig. 664), which rests on a tripod, being used for the purpose. Some operators coat the whole surface of the wire with tin to prevent oxidation, but this is not absolutely necessary, as in most mouths the surface of the wire exposed to the oral fluids does not suffer to an extent beyond mere dislocation.

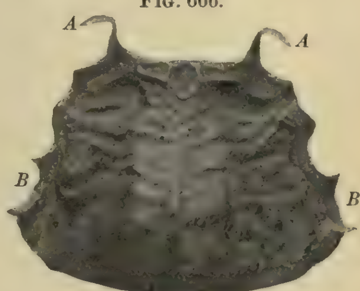
In speaking of the construction of these appliances Mr. Coffin[1] says: "The perfection of the model must be insisted upon, as an entire plate may fit well and securely, and yet both of its halves be so loose when divided as to be useless; while, on the other hand, the halves of a split plate may be early fitted which before division could not possibly be inserted." Mr. Coffin recommends gutta-percha as the best material with which to obtain impressions, on account of its slight contraction in cooling, which affords shrinkage enough to ensure the thin hard-rubber copy fitting tightly. As a rule, gutta-percha is unreliable as an impression material, and the author believes that a perfect plaster impression will always afford the most satisfactory results.

Fig. 665 illustrates a regulating apparatus formed of vulcanite covering the deciduous and first permanent molars, arranged with a gold T-piece, which is provided with a threaded end and a nut for the pur-

Fig. 665.

T-pins with nut to draw in protruding centrals.

Fig. 666.



Shows gold hooks for retaining lateral incisor.

pose of gradually increasing pressure upon the projecting teeth and drawing them into proper position. This plate may also be worn as a retaining plate to hold the teeth in position until they become permanently fixed.

Fig. 666 shows a vulcanite retaining plate designed to hold in position the lateral incisors, which have been drawn into correct position by means of rubber ligatures attached to a gold button in the palatal portion of the plate, as seen in Fig. 667. The hooks at *A* are of gold with perforated ends imbedded in the vulcanite. The half-clasps or stays at *B* are intended to rest against the second deciduous molars.

It is always difficult to secure a plate by contact with the temporary teeth, owing to their tapering forms. It is therefore necessary, where efforts are being made to correct irregularities in very young mouths, to

[1] *Dental Cosmos*, vol. xxiv. p. 466.

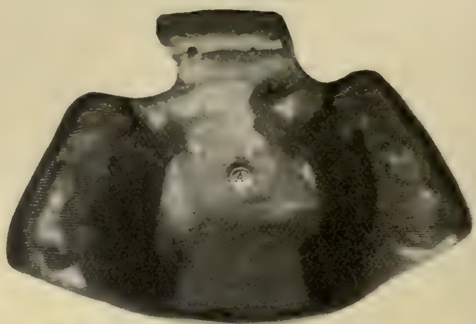
secure them by means of gold clasps or stays. These should be made to extend somewhat under the free margin of the gums, so as to embrace the most prominent part of the teeth thus; and to accomplish this the model should be carved away at the margin of the gum, as shown in Fig. 666, in order that the clasp or stay may be fitted to the part of the tooth indicated.

Fig. 668 illustrates a vulcanite plate to be applied to cases where the central incisors require forcing outward, while the projecting laterals are

FIG. 667.

Retaining plate No. 8.

FIG. 668.

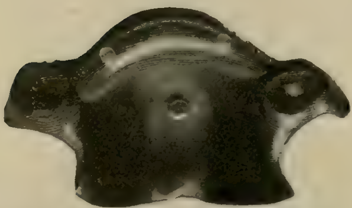


To force out centrals by means of screws and at the same time to draw in laterals by means of rubber.

to be drawn in until they line with the cuspids. This plate is made to cover the lingual surfaces of the centrals to their cutting edges. The portion immediately back of the central teeth should be at least an eighth of an inch in thickness. As the means of forcing out the front teeth consists of gold screws held in the rubber, it is therefore necessary that the material at that point should be of sufficient thickness to afford a secure hold. The plate is constructed so as to cover the bicuspids and first molars, partly for the sake of security and partly because the force of occlusion assists in forcing out the centrals. When the plate is ready for adjustment holes are drilled in the vulcanite back of the central teeth, and stout gold screws of the thickness of No. 17 or 18 are screwed into the vulcanite. It is not necessary to cut a thread in the rubber; the gold screw will force a thread without previous tapping. The screw should project at the point of contact with the lingual surfaces of the centrals, at first about the twentieth of an inch, and every day or two the screw may be lengthened by grasping it with the pliers and by a turn or two increasing the stress upon the teeth. The lateral teeth may be brought into correct position at the same time by attaching two rubber rings cut from a piece of French rubber tubing and tied with a strong linen thread to the gold button *A* of Fig. 668, and then stretched out so as to engage the lateral teeth. When rubber ligatures are employed in connection with vulcanite plates, provision should be made to prevent the ligature from resting upon and irritating the tissues between the lingual surfaces of the teeth and the edge of the plate. It is sometimes necessary to attach a supplementary piece to the plate at the point indicated, to keep the ligatures from injuring the gum (Fig. 669). The gum is very liable to thicken up as the protruding teeth are drawn inward.

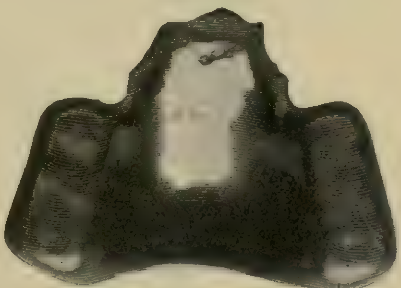
The screw (Fig. 670) may be used in connection with the T-piece (Fig. 665) in rotating a single central tooth by applying the force at opposite points on the tooth, and this is done by lengthening the screw.

Fig. 669.



Bridge added to plate by riveting to relieve pressure of rubber ligatures.

Fig. 670.



To force out centrals.

Kingsley's slotted vulcanite plate, with jack-screw, shown by Figs. 671–673, is another example of the value of vulcanite in the formation of regulating appliances. Fig. 671 is designed to move outward a left

Fig. 671.

superior second bicuspid; Fig. 672, to move outward both inferior bicuspids of the left side, the first more than the second; Fig. 673 was intended to operate upon all four of the inferior bicuspids.

Fig. 672.

Fig. 673.

Kingsley's slotted vulcanite plates with jack-screw.

One of the most effective vulcanite regulating appliances was devised by Dr. Louis Jack (Fig. 674) for the treatment of excessive protrusion

of the superior incisors and cuspids, so frequently met with, and which is variously attributed to the habit of thumb-sucking, unusual shortness of bicuspids and molars, absence of normal power in the orbicularis oris muscle, etc. (See Fig. 674.) It consists of a strong gold bar passing around the labial surfaces of the incisors, attached to vulcanite caps fitting over the bicuspids and first molar on each side. As will be seen in the illus-

Fig. 674.

tration, the caps are formed of gold on the masticating surfaces, so that the caps will not be broken by the forcible closure of the lower teeth. On the outside of the right cap is a threaded cylinder, into which fits a stout screw at the end of the gold bar: stress is brought to bear upon the front teeth by simply giving the right cap a turn or two, which shortens the bar. The gold portion of the appliance is imbedded in vulcanite in order to secure accuracy of adaptation of the caps to the teeth. This appliance is particularly effective in those cases where it is necessary to obtain room by the extraction of the right and left first bicuspids. The spaces left by the removal of the teeth are very quickly closed by the gradual force applied by this apparatus, and the six anterior teeth are drawn bodily into correct position.

The same appliance may be satisfactorily used to move outward the lower anterior teeth by arranging the bar so that force may be exerted against the lingual surface of the teeth.

After the proper position of the teeth has been secured the appliance is to be worn for several months as a retaining fixture. In constructing this appliance the first step is to place softened sheet wax upon the crowns of the teeth to be embraced by the caps: this is pressed with the thumb to complete contact with the plaster teeth; a zinc die and lead counter-die are then secured, and the platinum gold plate swaged to cover the crowns of the teeth over the wax. The bar is soldered to the left-hand cap, and the threaded cylinder to the other. The gold caps with the bar attached are then placed upon the model. The wax previously placed upon the masticating surfaces of bicuspids and molars will raise the caps sufficiently from the plaster teeth to allow an equal thickness of vulcanite to interpose between the gold and the teeth. Additional wax is added to finish out the caps to the desired dimensions. The piece is then flasked, packed, and vulcanized. By this combination strength is secured by the use of the gold plate upon the

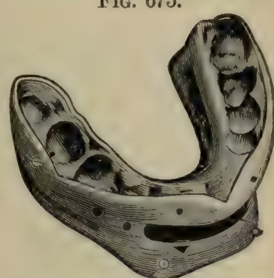
masticating surfaces, while closeness of adaptation is obtained by the vulcanite.

In flasking the piece it should be arranged so that the fixture remains in the second half of the flask, the first half holding the plaster model only. The best way to accomplish this is to cut away all the plaster teeth from the model anterior to those embraced by the caps; when removed to the margins of the gums the bar is free to be enveloped by the plaster investment when flasking, and when the flask is opened preparatory to packing the only part exposed will be the gold plate which forms the tops of the caps, while in the first half of the flask the teeth to be covered will alone be visible.

Interdental Splints.

Interdental splints in conjunction with submental compresses and occipito-mental bandages have been used by surgeons in the treatment of fractured jaws since 1780.

Fig. 675.



Gunning interdental splint.

Drs. F. B. Gunning of New York and J. B. Bean of Atlanta, Georgia, were the first to describe methods of constructing interdental splints of vulcanized rubber. Both of these gentlemen claimed priority, and it appears that the invention was made and published independently by each at about the same period.

The interdental splints of Drs. Gunning and Bean were similar, except that the arrangement of the submental compress and bandage of Dr. Bean differed materially from that used by Dr. Gunning.

The Gunning splint (Fig. 675) covered both the upper and lower teeth, and was provided with an opening in front for the reception of food, a bandage over the head being used as a means of securing adjustment of the lower jaw with the splint. Other splints were used by Dr. Gunning which covered the lower teeth only, leaving the motions of the jaw free. Fig. 676 shows the arrangement of the mental compress and bandages employed by Dr. Bean to maintain the relation of the jaws.

Fig. 676.

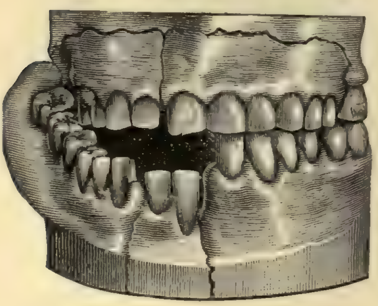
The preliminary steps in the treatment of fractures of the jaw are generally made more or less difficult by the pain and swelling incident to the injury. For the impression, plaster of Paris is by far the most suitable material, as it necessitates less bulk and may be applied with much less force than is required to press wax or modelling compound to complete contact with the teeth. If plaster of Paris be intelligently and skilfully employed in these cases, no violence need be used either in its application or removal. An impression-cup of

the proper size, with a smooth and polished surface, should be selected and oiled to ensure its easy separation from the plaster when hard. The latter should be of the finely-ground variety, such as is furnished by the dental dépôts for impression purposes, and which hardens quickly, breaks with a sharp fracture, and requires but little force in its removal.

The cup, filled sufficiently with plaster, is applied while the latter is still quite soft, and held until it sets. The cup is then separated from the plaster with scarcely any force; the plaster impression is gently removed in pieces from around the teeth, and placed in their proper relation to each other in the cup. If any of the teeth have been loosened by the injury to the jaw, the use of plaster of Paris is especially indicated in order to avoid their displacement by the downward pressure of wax or modelling compound.

If the fracture be of a complicated nature and accompanied with considerable displacement of the parts, as shown in Fig. 677, no persistent effort need be made to restore the deranged fragments, as that part of the operation can be just as well accomplished on the plaster model, the patient being thus relieved from the additional suffering which would be sure to attend any attempt to set the broken parts of the jaw.

FIG. 677.



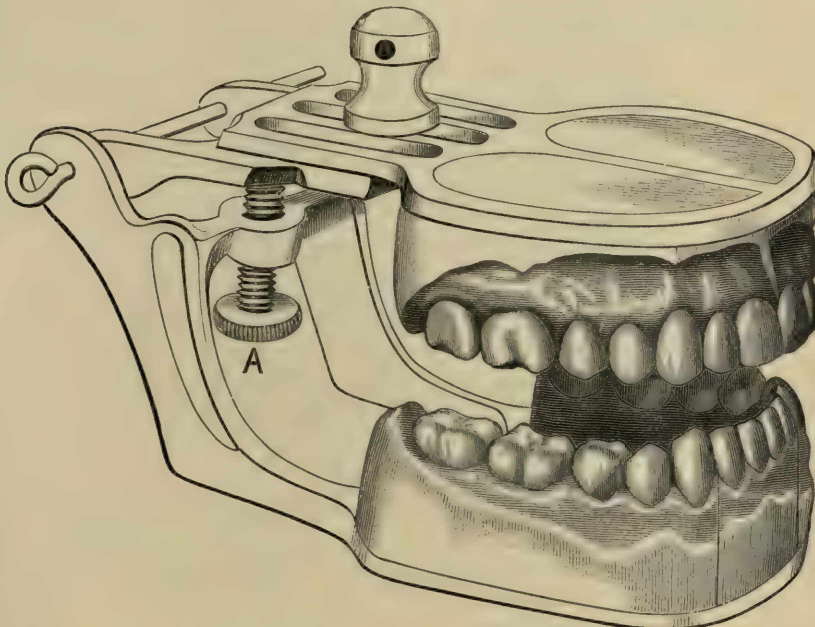
An impression is then taken of the upper teeth, the positions of which, even when the superior maxilla is broken, are not likely to be changed. When the models have been obtained cuts may be made with a fine saw through the model of the lower jaw at points corresponding with the fractures, and the articulation corrected by adjustment to the upper teeth, which will serve the operator as infallible guides. The parts of the lower model are then secured in their corrected relation by additional plaster: no effort need be made to set the jaw after the impression is taken until the splint is ready for adjustment.

To preserve the proper relation of the lower to the upper teeth, the models should be placed in an articulator (Fig. 678).

The set screw of the articulator should be arranged so as to allow of a separation between the upper and lower teeth of about a quarter of an inch. While it is desirable that the splint when finished should fit the teeth and gums with sufficient closeness to enable it to serve the purpose for which it is designed, it must be borne in mind that to save the patient from additional pain in its adjustment it is necessary that the fixture should go immediately to its place, without delay or repeated trials. To accomplish this, the plaster teeth and gums for about a quarter of an inch above the necks should be carefully covered with No. 60 tin-foil, for the purpose of slightly enlarging the splint and to secure a smooth surface to the inside of it. Interdental dovetail spaces may be arranged by filling the undercuts with plaster before applying the foil, or by trimming away retaining points in the finished piece with a sharp knife-blade or engine bur, so that the splint may be applied or removed

without much force. The splints are then formed on the plaster models of thin sheet wax of a uniform thickness slightly in excess of a sixteenth

Fig. 678.



of an inch: wax of a sufficient thickness is then placed between for the purpose of uniting them, as shown by Fig. 679.

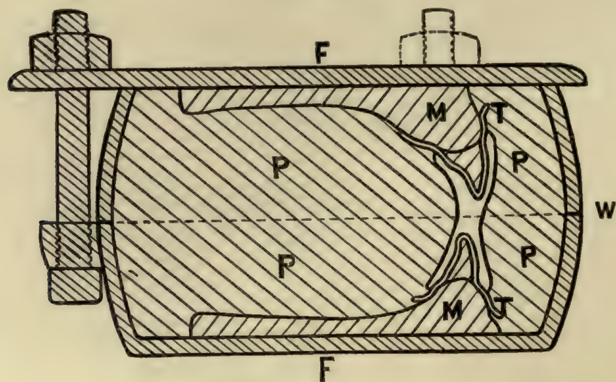
Fig. 679.

The upper and lower splints are to be carefully united and made perfectly smooth by means of a hot spatula.

The wax splint is next to be removed from the models and invested in a suitable flask in the usual way. The models may be removed from the articulator for the purpose of vulcanizing upon them; this, however, is not really necessary. It is, indeed, a better plan to preserve the

models and articulation to assist in the preparation of the finished splint for final adjustment. Much the better way is to carefully fill the deep parts of the wax splint with plaster by means of a camel's-hair brush, and then invest with the line of division at about the middle, as shown by the dotted line in Fig. 680.

Fig. 680.



The tin-foil should extend about an eighth of an inch beyond the wax; it will thus be held securely by the investment, and disarrangement when the flask is separated for the removal of the wax will be avoided.

A sectional view of the flask with the invested splint is given in Fig. 680. The flask is shown by *F;* the models by *M;* the plaster investment by *P;* tin-foil covering the teeth with extension beyond the wax splint by *T;* the wax pattern of splint by *W*.

The same precautions recommended for the waxing, flasking, and packing of ordinary vulcanite dentures should be observed in the construction of splints, but especial care should be observed in the separation of the flask to avoid breaking the thin plaster teeth, as such an accident would greatly embarrass the subsequent steps of the operation.

The flask should therefore, previous to any attempt to separate it, be placed in hot water, and allowed to remain until the wax is quite soft. After the separation the last particle of wax should be washed away by means of a stream of boiling water.

The packing of the rubber demands more than ordinary care to ensure its being carried into the deep and narrow spaces around the teeth. The rubber should be cut into thin strips, softened over boiling water, and carried into the matrix by a suitable instrument, such as an old plugger. There should, of course, be a slight excess of rubber. The vents may be as for ordinary dentures.

Interdental splints need not be thicker than is consistent with sufficient strength. They should be well finished, and provided, when admissible, with a front opening, as shown in Fig. 679, large enough for the passage of a feeding-tube.

An interdental splint cannot usually be relied upon to immovably retain the broken jaw without the assistance of bandages, screws,

wires, or ligatures. Fig. 681 (Kingsley's *Oral Deformities*) shows the use of screws passed through the splint at points between the cervical portions of the crowns of the molar teeth.

FIG. 681.

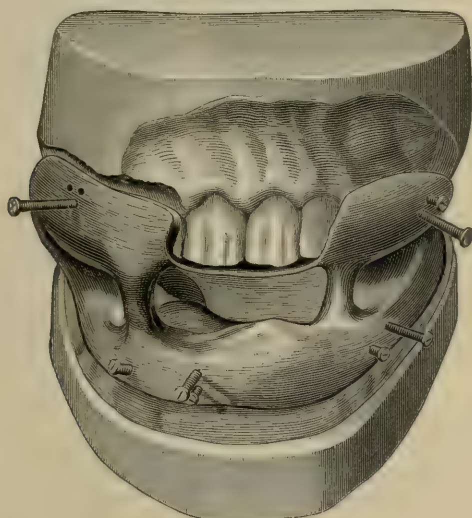


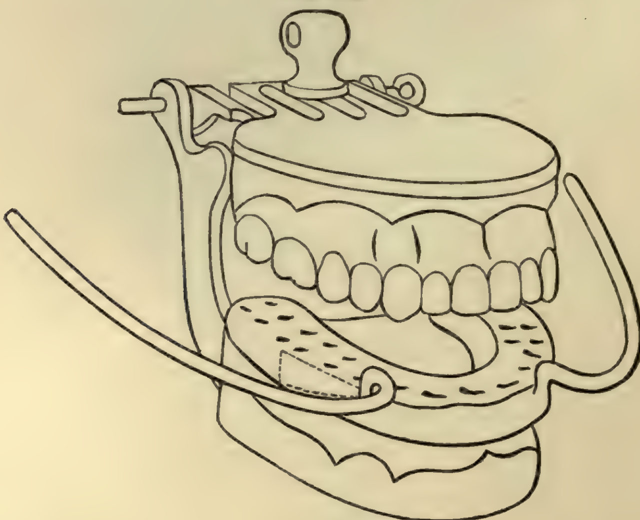
Fig. 682 (*ibid.*) illustrates a splint provided with arms of steel wire one-eighth of an inch in diameter, arranged to come "out of the

FIG. 682.

mouth when the splint is in position, passing back along the cheek on a line with the teeth." This splint was invented by Dr. Norman W. Kingsley, and the description of it, with the illustration, is from his valuable work on *Oral Deformities*. Fig. 682 shows the splint in position and the submental compress attached to the side-bars.

It will be seen that this splint covers the lower teeth only, and that its top occludes with the upper teeth to admit of mastication. The construction of such a splint is accomplished by placing upper and lower models in an articulator, forming the wax splint as before described, arranging the occlusion so that contact of the upper teeth will be uniform, imbedding two stout steel wires with flattened ends in the wax, so that they will bear the strain which will be required of them while the splint is in position. Fig. 683 shows the waxed splint with side-bars in

FIG. 683.



the articulator ready for investment. The particular flask best adapted for the vulcanizing of interdental splints is oblong in form, and is larger than ordinary vulcanite flasks; it is known as the "box flask."

CHAPTER XVI.

CELLULOID AND ZYLONITE.

BY W. W. EVANS, M. D., D. D. S.

Celluloid and Zylonite—a distinction without a difference. In these two materials—alike and yet not alike—we have a compound from which are made dental base-plates as well as numerous other articles. This compound will supply many requirements which no other substance now known to the profession fills. Yet it is but little understood, and there are many drawbacks to its wide use.

HISTORY.—Pelouze, with a genius for discoveries, found that paper treated with concentrated nitric acid instead of being decomposed retained its form, assuming a parchment-like appearance and flashing into vapor when brought into contact with flame.

Jacobi of St. Petersburg, experimenting with ozone and observing the passivity of iron in concentrated acids, was induced to try the effect of these acids on organic matters. As a result he patented the discovery of gun-cotton. This was in 1847. Jacobi had simply followed in the footsteps of Pelouze: the second discovery was in no wise greater than the first.

Baron Lenz of Austria brought the gun-cotton discovery of Jacobi into practical use. The Austrian government later on carried it to a more perfect state.

Abel of England also made valuable improvements in the process of manufacture, and, it was reported, sold his patents to Messrs. Prentice, gunpowder manufacturers, for forty thousand pounds sterling. They, having a large fire in their factories at Waltham-on-Thames, met with sad loss of life from explosion of the gun-cotton, which they were under the impression was not explosive. This was a deathblow to its manufacture for several years. In the mean time the manufacture of nitroglycerin had made great progress.

Hadon, after a minute examination of cellulose as manufactured for surgical purposes, found that in some hands it was frequently a failure. This led him to the inference that there were several preparations of nitro-cellulose, instead of simply a more or less perfect "gun-cotton." He found that cellulose could be converted into three products by means of nitric acid diffused in sulphuric acid of varying strengths, thus modifying its action. These three products chemists usually designate under the generic name of pyroxylins. They are all nitric ethers of cellulose. They are mononitro-cellulose, dinitro-cellulose, trinitro-cellulose.[1]

[1] The dinitro-cellulose or pyroxylin of the U. S. P. is made by macerating for fifteen hours half a troy-ounce of cotton in a mixture of four troy-ounces of sulphuric acid

The manufacture of the dinitro-cellulose must be a very delicate operation, as the following quotations from some notes furnished me will show: "Temperature of combination, absence of water (hygroscopic) in the paper or cotton, state of division, concentration more or less of the acid—$\frac{1}{2}$ of 1 per cent. of water being capable of producing a totally different product—render the manufacture of the dinitro-cellulose a very nice operation, to that extent that two years ago experts who manufactured these products for photographic purposes asserted that it seemed impossible to prepare two samples exactly alike.

"On the one hand, dry weather and very concentrated nitric acid render the product hard—*i. e.* insoluble in the test-liquor of 1 part camphor and 20 parts alcohol—and, on the other hand, weakening acids by absorption of water from the atmosphere alone produces zyloidin or mononitro-celluloid, soluble in the acids, and, instead of the average 40 per cent. increase, the manufacturer finds an increase of only 18 per cent. and a tendency to rapid change. It requires the knowledge and skill of a very observant operative to remedy these defects, and without correct conceptions of the possible causes of these changes he is very apt to despair."

The extreme tenacity of the film of collodion, it being a colorless transparent material not affected by moisture, suggested its application as a factor in the arts, but the cost of its solvent—namely, 2 parts ether and 1 part alcohol, both lost by evaporation—was prohibitory.

It is said that an Englishman named Parkes made the first celluloid in 1855, calling it parkesite, zylonite, etc. D. Spill also claims the discovery that a solution of camphor in alcohol dissolved collodion, on the strength of which he took out patents. It was afterward found that wood alcohol was also a solvent.

But the first practical knowledge which we have of the material was in 1869. Under the management of Mr. J. Smith Hyatt the Newark Celluloid Manufacturing Company was organized: this company spent large sums of money in experimenting and perfecting the process of manufacture; they met with accidents and disappointments at first, but were finally successful in their efforts.

and three and a half troy-ounces of nitric acid, afterward washing the cotton repeatedly until all free acid is removed, and then drying by means of a water-bath.

The action of nitric acid in the formation of each of the nitro-cellulin compounds is represented in the following equations from Attfield's *Chemistry* (p. 398):

$$\underset{\text{Cellulin.}}{C_6H_{10}O_5} + \underset{\text{Nitric acid.}}{HNO_3} = \underset{\text{Mononitro-cellulin.}}{C_6\left\{\begin{matrix}H_9\\NO_2\end{matrix}\right\}O_5} + \underset{\text{Water.}}{H_2O}.$$

$$\underset{\text{Cellulin.}}{C_6H_{10}O_5} + \underset{\text{Nitric acid.}}{2HNO_3} = \underset{\text{Dinitro-cellulin.}}{C_6\left\{\begin{matrix}H_8\\2NO_2\end{matrix}\right\}O_5} + \underset{\text{Water.}}{2H_2O}.$$

$$\underset{\text{Cellulin.}}{C_6H_{10}O_5} + \underset{\text{Nitric acid.}}{3HNO_3} = \underset{\text{Trinitro-cellulin.}}{C_6\left\{\begin{matrix}H_7\\3NO_3\end{matrix}\right\}O_5} + \underset{\text{Water.}}{3H_2O}.$$

As seen in the equations, one, two, and three molecules of peroxide of nitrogen, NO_2, are substituted for one, two, and three atoms of hydrogen respectively, one, two, and three molecules of water being severally formed in the reaction. The purpose of the admixture of sulphuric acid with the nitric acid is to free the latter from the presence of the water formed, sulphuric acid through its affinity for that fluid readily taking it up. Of these three nitro-cellulin compounds, the dinitro-cellulin is the only one soluble in a mixture of alcohol and ether, this solution forming the collodion of commerce.

The American Zylonite Company is justly noted for the beauty, uniformity, and strength of the material it produces.

As now manufactured, celluloid is composed of pyroxylin, camphor, oxide of zinc, and vermilion, in the proportions of about 100 parts of pyroxylin, 40 of camphor, 2 of oxide of zinc, and .06 of vermilion. A very good description of the process of manufacture of the article and of its more important properties will be found in an extract from the *American Artisan*, given in the *Dental Cosmos* for January, 1875, extracts from which are quoted below, although the opinion therein expressed, that the celluloid is a chemical combination of the constituents named above, is not generally accepted, as far as dental blanks are concerned, for certain recent experiments with the microscope have led to the belief that it is simply a mechanical admixture. It says:

"After the pulp is ground in the beater-engine, and the camphor and whatever coloring material may be desired are thoroughly incorporated with it, the substance being kept meanwhile at the proper temperature, the superfluous water is removed by pressure and absorption, a peculiar porous material made specially for the latter purpose being employed.

"During the process of drying under pressure and absorption the material becomes transformed, so that it is no longer nitro-cellulose, but imperfect celluloid. In so far as conversion has taken place, its properties have undergone a total change. All that remains to convert it into the various articles referred to is manipulation under heat and pressure, during which process the chemical combination is completed.

"For some qualities of the material, desired to be produced, a small percentage of alcohol is added in the subsequent manipulation. As evidence that there is a perfect chemical combination, and not a mere mechanical mixture of the materials, it may be stated that whereas camphor in its uncombined state is an extremely volatile substance when exposed to the air, in its combination with nitro-cellulose it loses this property altogether. An enumeration of the properties of the material which will be given anon will be further proof of the chemical combination. When the material is properly converted comparatively no shrinkage takes place. There is no escape of the camphor unless an excess has been employed, and in that case the excess of camphor will escape from the surface of the celluloid; but whatever uncombined camphor remains in the interior is so closely imprisoned by the solid surfaces that it cannot escape. By varying the proportions of the excess of camphor different degrees of solidity and flexibility are obtained."

The properties of celluloid (noted in the same article) are as follows:

"Without the admixture of coloring material it has a pale amber color. If it is desired to make the material white like ivory, oxide of zinc is added, and for other colors various mineral pigments are incorporated with it, or dyes soluble in alcohol or any of the aniline dyes may be caused to permeate the material to give it any desired color. It is hard and elastic, having a hardness ranging from that of horn to that of ivory. It is as tough as whalebone. In elasticity it greatly exceeds ivory. . . . .

"Celluloid is also a very fair non-conductor of heat and electricity—not equalling hard rubber, but approximating the latter very closely in

this particular. . . . . Although a good non-conductor, it is not perceptibly electric. . . . .

"But perhaps the most remarkable property of this material is the fact that it becomes plastic at a temperature of from 250° to 300°, and this property enables it to be moulded with facility into a great variety of forms. Pure celluloid has a specific gravity of about 1.4.

"A profitable and successful industry based upon these properties of celluloid is the manufacture of dental plates. The material may be made precisely the color of the natural palate and gums. It is much stronger than rubber, and has a perfectly clean surface. It may be manipulated more easily than rubber. It possesses many of the valuable qualities of rubber for dental purposes without its defects. It requires only about one-sixtieth as much vermilion to give the proper color to celluloid as is required to impart the usual color to rubber. The difficulties encountered in the application of celluloid to dental plates have been very great, but the inventors continued experimenting until during the last few years they claim to have produced an article possessing all the requirements desired."

The first process for moulding celluloid into dental plates was that known as the oil-bath. The oil was placed in a small cast-iron box or tank containing the flask, and the whole was heated to the boiling-point, the flask being gradually closed by means of a clamp.

Next was the glycerin process. This certainly was an improvement, for if a good quality of the material was employed and perfect cleanliness preserved, there was no unpleasant smell and the glycerin was not liable to become rancid, and, being readily soluble in water, the flask could be kept free from dirt. This process is still used by many dentists, the machines, etc., employed in it having been much improved.

The two remaining methods of moulding this material are by steam and by dry heat.

Dr. I. H. Alexander was doubtless the first to employ steam in the manipulation of celluloid.[1]

It is useless to describe the steam-heat, oil, or glycerin process for dental purposes, as they are primitive and obsolete.

The dry-heat process now in general use is the one which gives most satisfactory results, the proof of the correctness of which opinion will be clearly shown later.

The credit of having originated this method belongs to Dr. R. Findley Hunt of Washington, D. C., though other gentlemen have made claims to the discovery. Whoever may have first conceived the idea of this process, however, it is certain that Dr. Hunt practically applied it first, and his were the first machines known to the public.

There are several dry-heat machines at present in use: the most desirable one, however, is known as the "Best." The advantage of this machine over all others lies in the fact that in carrying the heat as high as is necessary to thoroughly soften the celluloid the danger of combustion of the highly inflammable substance is avoided. If an apparatus is used that so confines the flask that it cannot readily be removed from the overheated oven at will, an explosion, resulting in the total destruc-

[1] *Dental Cosmos*, May, 1875, p. 280.

tion of the carefully prepared work may occur. The construction of the "Best" apparatus permits of the instant removal of the flask if the heat is too great for safety, while the plate remains under pressure, owing to the screw-clamp being attached to the top. Another advantage is that the work can be readily examined from all sides. The illustration (Fig. 684)

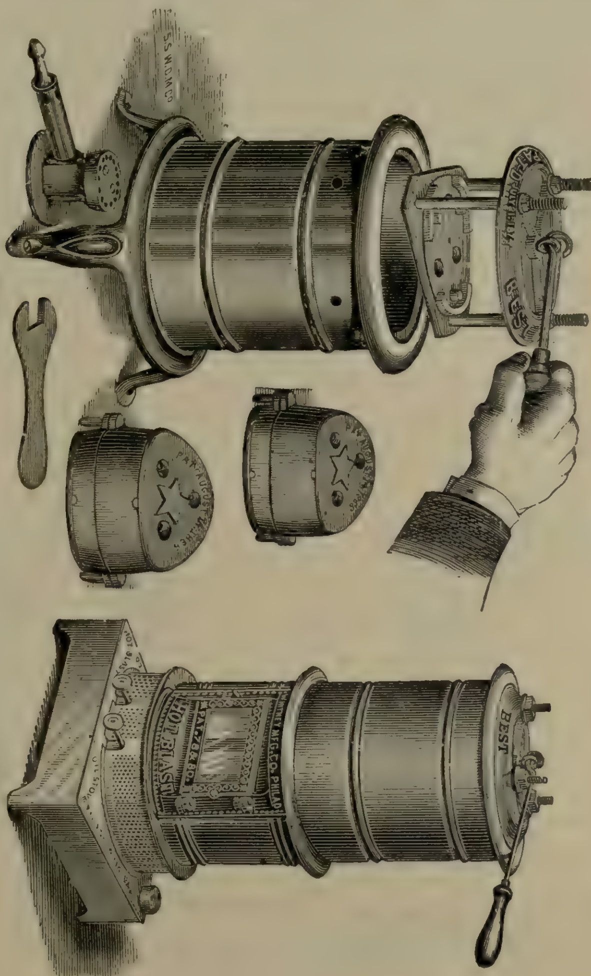


Fig. 684.

For gas. "Best" hot moist-air celluloid apparatus. For kerosene.

is so comprehensive as to scarcely need explanation. The bottom plate is connected with the top by three wrought-iron screw-bolts, the nuts being on the upper side and easy of access. When these nuts are turned for the purpose of closing the clamp, the bottom portion is drawn away from the flame and from the overheated bottom of the oven, thus gradually decreasing the heat without disturbing the flame.

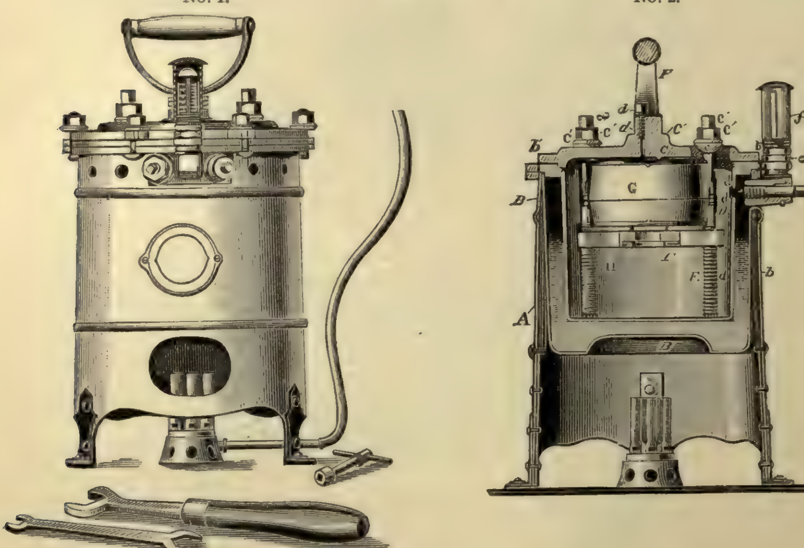
Equally desirable ovens for baking celluloid are those which have a dry oven surrounded by steam. Machines so constructed have the following advantages: First, danger of burning the plate is avoided, in

which respect they are safer than the dry-air chambers; secondly, the temperature may be carried to a much higher degree, a more thorough softening of the material be attained, and the two parts of the flask be brought together with greater facility.

Of these, the two most satisfactory are the "New Mode" heater of Dr. J. S. Campbell and one devised by the writer. The former of these is well known; the latter, shown in Fig. 685, is described as follows: No. 1 shows a front elevation of the machine ready for use, with top fastened down, and tools used in its manipulation. No. 2 illustrates a transverse vertical section with one flask in position, showing the manner of working zylonite, celluloid, or other material. *A* is a light casing surrounding and supporting the apparatus. *B* is the boiler, composed of two separable cups of best quality gun-metal, *b b*, united concentrically by screws, *b′*, to form a water and steam space. The object of this form of construction is obvious. It avoids complicated coring in casting; both sections may be examined before being fitted together, thereby rendering it certain that sound castings are employed, which aid greatly in ensuring safety in the use of the apparatus. The boiler, *A*, is made

Fig. 685.

No. 1. No. 2.



partly concave; thus, contracting the water space in the interior, so that steam is not only produced more rapidly, but is kept in a state of agitation, thus producing a more desirable quality of heat. *D* illustrates the oven, composed of the inner cup, *b*, having a cover *C*, an inlet for steam *d* through the cup *b* from the boiler, and an exit for steam through the cover at *d″*, both openings being controlled by valves *d′* and *d‴*. *E E*, the bolts, represent the next great feature of safety and convenience in this machine: their heads are spherical at *c*, the point of contact with the cover *c*, which has a corresponding socket to receive it, thus making a steam-tight joint. The top of the head *c″* is made to

fit the T-wrench, which also fits the different valves. Pressure from this is usually all that is required, but to make it applicable to the use of all an additional hexagonal portion c' has been made, whereby any amount of desirable pressure can be exerted. The lower portion of the bolt is threaded for one-half its length and screwed into or through the plate *F*, which is drawn toward the top by turning the bolts to the right, thus closing the flask or flasks with great facility and without the slightest strain upon the boiler, as must of necessity be the case with any apparatus having down-plungers which exert a strong leverage to force top and bottom asunder. *f* is the thermometer attached to the boiler by a ground joint and bevel-faced coupling, which makes a steam-tight joint and allows the face of the scale to come to the front. The bulb of the mercury tube is encased within a small copper tube passing down into the steam through the plug which enters into the boiler. This brings the mercury almost into direct contact with the steam, making it quite sensitive to changes of temperature, at the same time protecting the tube from fracture. The cup-like mouth of the plug also serves to fill the boiler with water.

On either side of the thermometer are the valves, one connecting the boiler with the oven, as before described; the other, a simple conical safety-valve, resting against a small hole through the plug into the boiler, and held in place by a heliacal spring, exteriorly adjusted by a perforated set-screw so arranged that the steam in the boiler can never go higher than the point at which you set the safety-valve without blowing off through the perforated screw-plug, thus preventing any possibility of explosion through neglect or carelessness.

I designates a handle whereby the top is readily removed to examine the work, etc.

The machine is simple, carefully adjusted, and having but one packing anywhere about it, is therefore not liable to get out of order.

It has plenty of room for two large flasks at a time, yet the outside measurement, case and all, is not over 10 inches high by $7\frac{1}{2}$ in diameter, and will readily stand from 250 to 300 pounds' pressure.

Use of the Evans Heater.

Having raised the heat to 320° in the boiler while preparing the work for moulding, put something between the jaws of the flask in order to keep them apart to facilitate drying, and place it on top of the plate in the oven, first noticing that the valve connecting boiler and oven is closed; then partly open the valve in the top, and leave the piece from half an hour to one hour to dry out; then raise the top and touch the flask with a wet finger; if hot enough to produce a hissing sound, the flask is ready for the blank. Having adjusted the blank between the two halves of the flask after trimming to the desired size, replace in the oven, leaving the lid loose, but nearly closing the top valve; in from ten to fifteen minutes gently turn the bolts with the T-wrench. If there is no resistance, close immediately; should there be much resistance, wait a few minutes longer, then turn first with the T-wrench; should the blank be a little heavy, use the long wrench, taking each bolt alternately after one turn, raising the top now and then to see if the flask

is closed. When done raise the lid, which, in reality, is a clamp or press separate and distinct from the boiler, and either set by to cool slowly, or plunge into water and cool immediately. Cooling slowly is the proper way to allow the newly moulded material to season. It will be observed that in the manipulation of the screw-press top of the machine the action is similar to that of the "Best" apparatus, and there is probably no way to materially improve on that device for safety and simplicity.

FIG. 686.

Set of carvers.

A simple form of lock flask is an advantage when more than one piece is to be moulded, as it may be locked, taken out of the press, and set by to cool, while work is continued with other pieces. The entire time consumed in drying out and closing the flask should not exceed an hour to an hour and a half. As no steam is lost from the boiler, a dozen pieces can be moulded, if desired, in a day. Any sized flasks, of any description, can be used, whether lock or otherwise.

Before proceeding to describe the method of working celluloid it may be well to give some further reasons why the peculiar dry heat produced by steam is superior to either a steam-bath or direct dry heat.

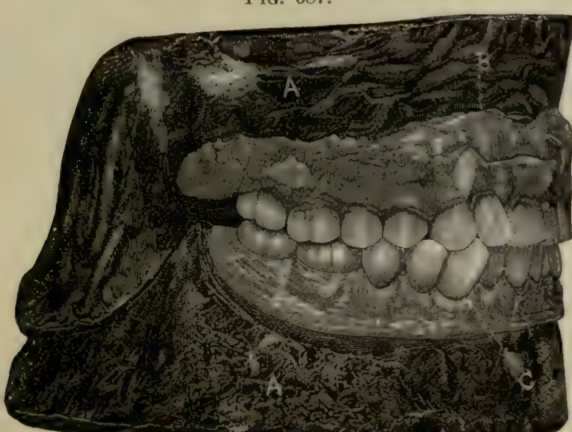
Celluloid is peculiar. To be properly managed it must be understood. It must be studied, manipulated carefully, and controlled, for it has a character of its own. Recent experiments of Professor Tarr of the Georgetown University lead to the belief that it is merely a mechanical admixture, the microscope showing very clearly the two most important constituents, camphor and gun-cotton, in their natural state. In these experiments thin specimens of pure celluloid before treatment and after being put into the heater were examined under a microscope having a power of three hundred diameters, and viewed by transmitted light revealed a structure irregular and grooved, with flinty appearance and protuberances of black specks. Stray threads of nitro-cellulose were noticed in some cases corresponding with the grooves. In one instance, the specimen having been disturbed, a fibre was displaced and the underlying groove distinctly seen. The same specimen seen by reflected

light displayed a clear, crystal-like surface, similar in appearance to a heap of small pieces of camphor, and the black specks noticed before were very like protruding shreds of cotton. This would seem to indicate that the pyroxylin and camphor had not united chemically, but were merely mechanically mixed, and by means of the great pressure exerted upon them formed into a solid mass. In order, however, to make assurance doubly sure, pieces of pure gun-cotton were examined under the same glass, and no distinction could be observed between them and those discovered in the celluloid. A thin, transparent wafer of camphor also was examined, and the appearance was exactly the same as that of the main body of the celluloid, without the black specks.

Before going farther into this portion of the subject an approved method of working celluloid and zylonite is to be described, the discussions of the causes of success and failures in manipulation will follow, together with an examination of the relative merits of celluloid and zylonite.

Imprimis, a good impression is indispensable. For taking impressions plaster is preferable in all cases, and by all means should be used where partial impressions are to be taken. No time or trouble should be spared in securing an accurate occlusion for the articulation. Having procured this solid foundation, next make upon the model a wax plate of the same thickness which the celluloid plate is to have, or a little thinner. Care in this particular is essential. The pink paraffin and wax for the purpose found in the dental dépôts in the form of thin sheets and in sticks is admirably adapted for this purpose. The reasons for using this wax rather than others are obvious: it is cleanly, does not soil or

FIG. 687.

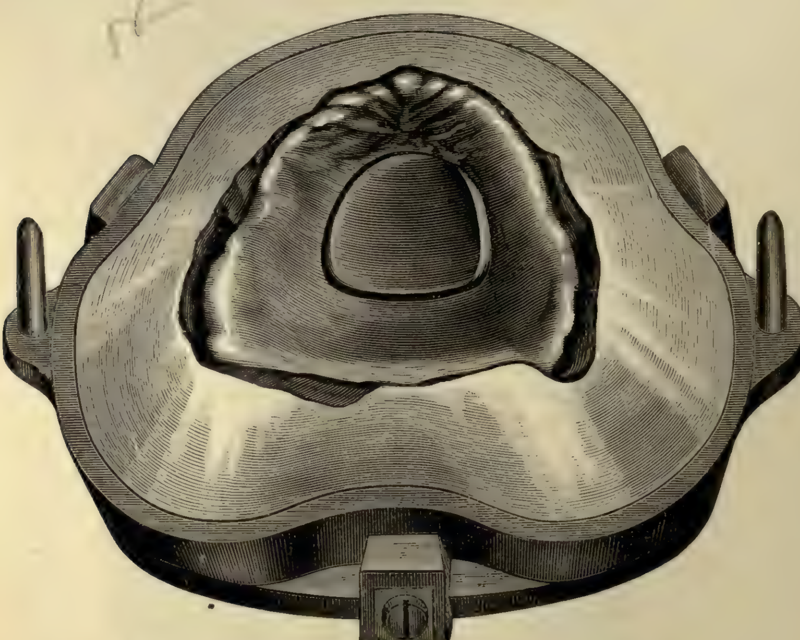


stick to the hands or teeth, is dry and carves well, and, as it is nearly the color of the gums, it serves as a convenient guide for modeling. In an upper plate only one thickness of the wax over the palatal portion is necessary. Warm the wax and press it gently over the model, exhibiting in relief any rugæ, etc. which may exist. Select the plain teeth made for celluloid, as they are probably the most natural in shape and shade of any now made for the purpose, and permit a greater display of

skill and taste than any others. The grinding and arrangement of the teeth are to be regulated by the features of the case in hand.

This is a distinct and extensive study in itself, and could scarcely be treated thoroughly under this head. The next step, the carving, is a very simple performance, provided sufficient study of the forms and arrangements of natural teeth has been made, together with observations of irregularities, effects of diseases, etc. With models representing these features before the operator, and a remembrance of the face of which it is intended to restore the features, the operation is not a difficult one. For use in carving three little double-end tools, represented in Fig. 686, are re-

Fig. 688.



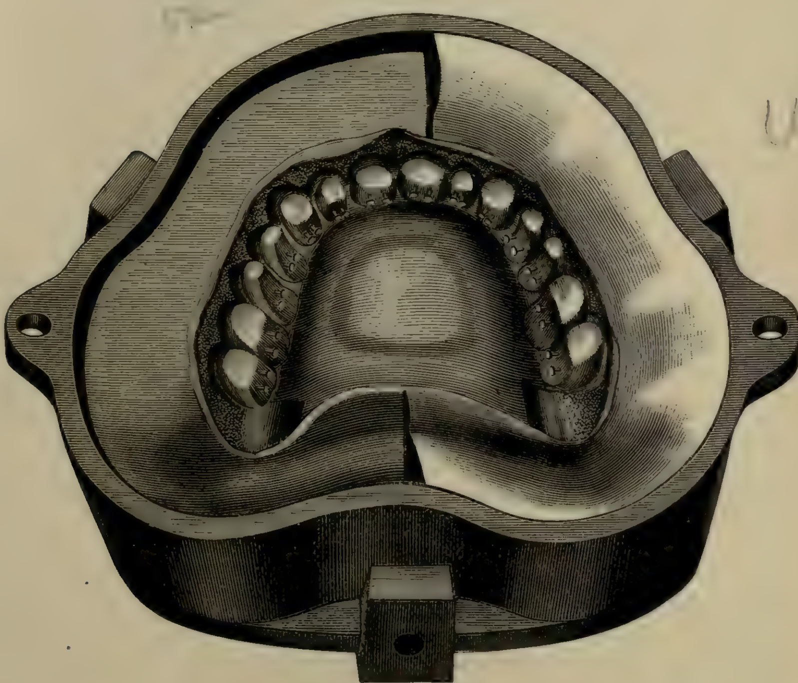
quired, the uses of each of the points of which will be explained. Fig. 687 presents a full set of teeth in process of carving, the upper half, shown by *B*, having on it the rough wax as dropped there while grinding and adjusting the teeth, the lower denture, at *C*, showing where the wax has been cut away from the teeth in scallops by the straight-bladed knife of carver No. 2, and roughly shaped up with the spoon end of the same instrument. Next is used the smaller spoon end of No. 1 to form the fossæ or depressions lying between the roots, and the curved knife-blade of the same to go around the teeth on the palatal side.

Having carved the wax in this way, forming festoons or exposing roots as the case may require, take a spirit-lamp with a small flame and an air-bulb (which is better than a blowpipe), and by gently puffing upon the wax smooth away the rough, irregular projections while retaining the larger undulations of the form desired. This case is now ready for the tin-foil and stippling. Take a strip of No. 60 tin-foil a little wider

than the outside surface of the gum, and by commencing at one side with the broad end of the ivory-pointed carver No. 3 burnish the tin down smoothly and uniformly over the entire surface, occasionally using the pointed end to work between the teeth, and the straight blade of carver No. 1 to cut the tin from around the teeth. The inside of the model is treated in the same way, except that a narrow V-shaped piece is cut from the tin before placing it on the palatal surface, to avoid folding, and that the entire outer edge of the plate is trimmed around. The stippling is done with an ordinary blunt-pointed excavator or with an engine-plugger which will give a reacting blow. If done delicately and closely, the effect of the stippling is very pleasing.

The investing of the piece in the flask seems simple enough, and yet

FIG. 689.



a few suggestions may be of benefit. Always mount the model high in the shallow half of the flask (see Fig. 688), for reasons hereafter explained. Pour the plaster—neither too thick nor too thin, but of about the consistence of syrup—until it reaches the lower edge of the plate, no higher. When sufficiently hard, trim and use liquid soap as a separating material, as varnish is more or less dirty and will soil the work. Place on the deep ring and pour in the plaster, taking care to have no air-bubbles. Then with a little stick (an ordinary wooden toothpick) stir gently to and fro around the outside of the teeth to work the plaster into every little crevice between them. Put on the top, wash the outside of the flask clean of the surplus plaster which has oozed out,

and place it under gentle pressure until set—say, for half an hour or more.

If there are any undercuts, put the flask into hot water a few moments before separating it, to soften the wax and prevent breakage. Having separated the flask, pour, from a pitcher or other convenient vessel with a spout, boiling water on the wax until all is washed out, taking care not to disturb the tin-foil.

There are several ways of cutting vents for surplus material, but the one illustrated in Fig. 689 is preferable—the upper half of the flask shown in Fig. 688. The wax has been washed out, exposing to view the roots of the teeth, platinum pins, etc. ready to receive the base-plate, the stippled tin-foil clinging to the sides of the plaster. *B* indicates a portion of plaster cut away, illustrating the manner of forming vents; in this cut it is only carried half around, so as to show before and after preparing. Commence by cutting a deep groove all around the piece close to the flask and gradually tapering up to the tin-foil or the margin of the plate, marked *C*. By this arrangement the material has free exit all around, yet may not come out too rapidly. The plaster margins are not likely to be broken away under pressure, as the vent runs out almost at a right angle, thus leaving solid walls. Another advantage in this form of vent is that after the two halves of the flask have been pressed home the surplus material parts readily from the piece, leaving very little to dress up.

The process of baking follows: it is unnecessary to describe the manner of conducting this by the steam method. To bake by dry heat requires perhaps a little longer than by other means, on account of the necessity of expelling the surplus moisture from the plaster in the flask. Place the flask in the dry oven, having first slipped two small spools over the guide-pins to keep the halves apart, and close up all the openings to the oven except the small valve communicating with the outer air from the dry chamber, as this must be left to carry off the steam generated from the moisture in the plaster. Then raise the steam in the boiler to 320° or 330°, and keep it there. This will give a temperature of about 300° in the dry chamber. Let the flask dry out for not more than an hour, and then when touched with a wet finger, as the laundress does her smoothing-iron, the same "sizzle" will be produced. The case is now ready for the celluloid blank, which must first be trimmed to the proper size, trying always to have a slight excess, but being careful not to have too much. It is a mistake to use a very great amount of pressure at any stage of the process. Replacing the flask containing the blank in the oven, leave it there from ten to fifteen minutes to soften; then try its resistance by carefully turning the bolts for that purpose. Be sure that the bolts work easily and are true. The sensation of touch upon the wrench is the surest index of the amount of pressure being employed; and this, in the beginning, should not be more than can be exerted with the thumb and finger. The operator may raise the lid and see if the blank is soft by touching it with an instrument. As soon as the material has become soft enough, close the flask immediately, occasionally resting a moment between the turns to give the zylonite time to spread. The operation of closing the flask usually occupies from five to twenty

minutes. When it is closed tightly—and pressure should not cease until it is tight, in order to retain a perfect articulation of the teeth—it is better to leave the case a few minutes under heat to season, when it may be taken out if in a lock-flask in the "New Mode" vulcanizer; or if in the Evans heater raise the top, which in reality forms a clamp or press, and set it out of the window or in some other cool place to temper down. If a lock-flask has been used, so much additional time can be gained, but the flask should never be cooled suddenly in practical work, and never be freed from pressure from the moment it is closed until perfectly cold: one causes warpage; the other, shrinkage from the teeth.

Care should be exercised in removing the piece from the flask, on account of the hardness the plaster acquires when subjected to the dry-heat process. Having taken off the top and bottom, lay the flask in warm water for a few minutes. Then press a knife-blade between the two rings, and a gentle movement will cause one or the other to leave the plaster, when the remaining one is easily detached by a few blows of a hammer on its wide edge: knowing the position of the teeth, it is now an easy matter to get the piece out whole. Wash off the plaster which may adhere to it, trim away the surplus, remove the tin-foil, and, finally, having scraped and smoothed the edges with felt and pumice-stone, produce a high polish of the entire surface with brush-wheels, pumice, and chalk, taking care not to use too much friction.

Repairing this material is not so difficult as it appears, the process being very similar to that employed in mending rubber. If the plate is comparatively new, having been lately made, there is no special need of a great deal of "dovetailing," as the material with its solvent will readily unite. If, however, the piece to be mended is old, scrape away the edges of the fracture, dovetail, and drill two or three holes through the plate, reaming them on the inner surface in order to clinch the material when it goes through. Then wax these holes smooth on the inner surface with paraffin and wax; restore the outer surface with the same material to the original shape, and with the new teeth, if any, in place, invest in a flask, covering all except the parts to be repaired. After separating the flask wash out the wax with boiling water, and moisten the portions previously covered with it with spirits of camphor or the liquid zylonite or celluloid, made of one part zylonite scraps in three parts spirit of camphor. Then, preparing a piece of new blank a trifle larger than is actually needed, soak it in the camphor mixture until it becomes sticky, place it in position between the two halves of a flask, and heat the whole in the oven, as directed, twenty minutes or half an hour, and screw home. If steam be used, but a few minutes need be allowed to soften the celluloid, and then the flask may be immediately closed. By pursuing this course, taking care to have everything clean, absolute mechanical union will be obtained, unless the piece is quite old or has been baked by one of the liquid processes or by steam. It sometimes happens that through a desire to be too exact not quite enough material is used, a pin or two may be left partly exposed, a slight corner left out, or some other little defect of a like sort caused—not enough to interfere with the fit of the plate or to loosen a tooth, but enough to annoy the critical sense of one who appreciates symmetry and a nice finish. To correct these slight blemishes use

zylonite filings moistened in spirits of camphor, and press gently into the inequalities with a heated burnisher—not too hot, by the way. Allow such pieces to stand a while before the final polishing and finishing. Another convenient way to put in a tooth without loss of time is to cut out the broken portions, dovetail, grind in the tooth, and unite to the plate with amalgam.

The following are a few of the more important of the queries made concerning this subject:

First, it has been inquired what kind of plaster should be used for models, and how can they be gotten quite hard. Use the ordinary best Newburg plaster employed by the plasterers in house-decorations, such as cornices, etc. It is strong, sufficiently fine and smooth, and if properly manipulated will make very hard models, the hardness of which is increased, if when they are dry and absorptive, they are dipped into a boiling solution of borax or into a solution of 1 part of silex in 5 of water.

Again, it is asked why and how should models be obtained quite smooth and free from air-bubbles, nicks, bruises, etc. The reason is, that the model represents the mouth exactly, or should do so, and that any blemish upon its surface must necessarily be transferred to the plate, and will afterward irritate the mucous membrane, if not materially affect the fit of the piece. This is a matter about which most dentists are usually very careless.

If vacuum-chambers are used, they should be carved from the impressions before pouring. It might perhaps be well, too, to answer here the question whether tin models should always be used. Much the better results are obtained by their employment, except where it is extremely inconvenient to do so; and for several reasons: First, a tin model under pressure with teeth and undercuts is not likely to break; second, the microscope reveals the fact that the surface of the celluloid is made more dense in structure where it comes in contact with tin or tin-foil than where simply pressed on plaster; third, tin-foil cannot be placed on the model without materially affecting the accuracy of the fit; and fourth, a model of the case can always be retained. A tin model—or a tin shell of a model, which is even better, because there is no perceptible shrinkage, is lighter, and takes less material—can be made in less than ten minutes if all the requisites are convenient. A sand matrix is made: and into it molten tin is poured: while the body of the tin mould is still fluid the matrix is inverted, permitting the fluid metal to run out, leaving a tin shell model.

One of the charges against celluloid is that it is not stable enough, but this charge does not seem to be founded on fact; for by comparing its durability with that of other substances the following conclusions have been reached: The mean durability of vulcanite plates is overestimated. A fair average of their life is very probably not more than eight to ten years. Of course, many last longer, but these are the exceptions, and many do not last a single year. Continuous gum, except as manipulated by experts, is continually breaking, and is decidedly expensive and annoying. Celluloid has been in existence, for dental plates at least, only about eighteen or twenty years, and yet many plates of this material have been worn with satisfaction for eight or ten years.

The warping of plates may be caused in several ways. If the material is pressed home under high pressure and at a low temperature, the plate, having yielded to the pressure, necessarily tends to revert to its original shape by reason of its great elasticity, no radical displacement of the particles having taken place. And if the flask is removed from under pressure before it is thoroughly cold, there is again a tendency to warp. Heating the plate with friction in polishing will also cause this evil, as it does with rubber. If these causes can be avoided, there is no reason why a plate should warp.

These accidents are the result of carelessness, but the waxing of plates can only be obviated by the use of that class of machines which permit of carrying the temperature high enough to make the material thoroughly plastic, so that it will yield readily to light pressure. In this state the cohesive force of the molecules of the body being reduced to a very small quantity, they will evince no tendency to return to their former position after a displacement, and a change may be produced in their relative positions which will become permanent when the cooling of the plate allows the force mentioned to again exert its influence. But it is claimed by the advocates of steam machines that this high temperature of 280° and upward is very injurious to the plates, and also that "too little pressure after the heat is up" will cause the same result—the puffing up, that is, of the material and its filling with air-cells, etc. These assertions are probably correct when applied to the process of moulding in steam, but when applied to the process in which celluloid or zylonite is softened in a dry chamber which is surrounded by steam they are not true.

It is believed that celluloid is cellular in structure, and, as a consequence, when it is heated and expands its cells absorb the surrounding medium as a sponge absorbs water. If this medium be oil or glycerin, the cells are filled with it, and the subsequent pressure serves to close their orifices without expelling the liquid. On cooling, consequently, the moisture throughout the interior of the substance softens the walls of the cells and they crumble away. If steam be used, when the plate cools the vapor is condensed and its expansive force becomes almost nothing, and therefore, in addition to the softening effects of the moisture, the walls of the cells are required to sustain the pressure of the atmosphere and of cohesion without any internal support. The celluloid ought, it would seem, therefore, to crumble even more rapidly. When, on the other hand, the plate is moulded in contact with dry air, while the cells still imbibe the surrounding medium, it is a medium without moisture, and of at least considerable expansive force even when cooled. The plate therefore remains smooth and compact.

The following figures were originally prepared from practical cases for illustrating an article in the *Dental Cosmos*, July, 1880, but as they were made with single teeth mounted upon celluloid base, they are reproduced to illustrate how perfectly this material with the use of single teeth can be moulded to restore expression in the human countenance. The illustrations are figured from practical models of characteristic mouths. Fig. 690 represents two sets of six front teeth from the same mould—one as it leaves the mould and is found in stock; the

other showing alterations by grinding to suit a different case. Figs. 691 and 694 represent two sets of mounted teeth, both from the same mould (shown in Fig. 690).

Fig. 690.

Fig. 691.

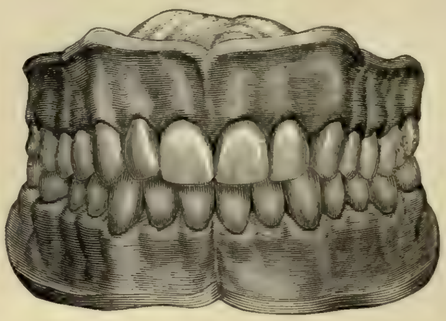


Fig. 691 represents a younger mouth than is often found requiring a full set of artificial teeth; but in order to show the different characteristics of youth and age which may be produced from the same set of teeth, the model of the denture of a young lady of about eighteen years of age was followed, reproducing the slight irregularities existing in her case. The artificial teeth illustrated in Fig. 690 were so well adapted to the case that very little modification by grinding was necessary, even the cusps of the bicuspids and molars scarcely requiring to be touched by the corundum wheel (see side view, Fig. 692), thus preserving the original form of the artificial teeth almost intact. The cutting edges have the rounded appearance so generally found in harmony with the general physique at this age, the serrations found at an earlier period having all disappeared. Fig. 693 shows a palatal view of the same case, and certainly indicates that a vast improvement of the grinding surfaces has been made by the manufacturer. The cusps and intervening sulci are clear and well formed, requiring in any case but little labor on the part of the dentist to make a perfect occlusion.

Fig. 692.

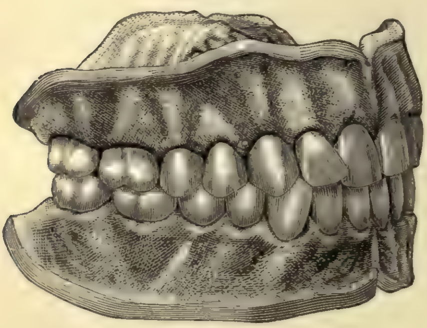
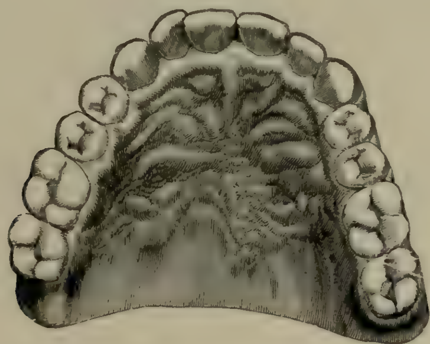


Fig. 694 shows the front view of a set of teeth for a male fifty or sixty years of age. It is somewhat of the Celtic order, though not what would be considered a pure type. This case has a "square bite" upon the cutting edges, producing slight abrasion, and with just enough irregularity to produce a pleasing effect. The gums show slight recession from the necks of the superior teeth, more marked in the inferior incisors and cuspids, and accompanied in the latter with a congestion of the gums, making the festoons more prominent than

normal. The prominence over the superior cuspids will strike some as being too great, but, considering the inclination of the roots and the contraction of the arch back of these teeth, it is not too marked, as is more clearly shown in Fig. 695, a side view of the same case. In

Fig. 693.



the lower maxilla the first molar is missing, and the second molar has moved forward just enough to adjust itself to a solid occlusion, the absorption of the alveolar process causing a greater recession of the gums at the necks of the second bicuspid and molar than else-

Fig. 694.

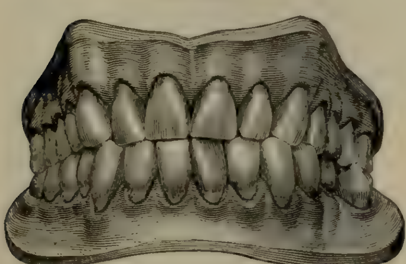
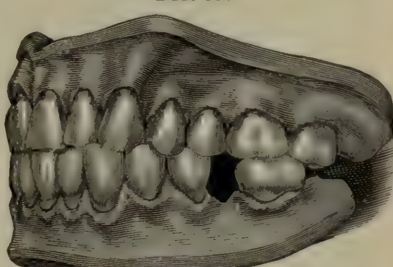


Fig. 695.

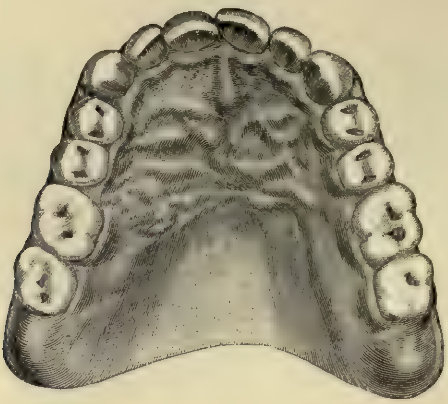


where. The abrasion of the cutting edges is best shown in Fig. 696, a palatal view of the same case, more marked upon the incisors and cuspids than upon the bicuspids and molars, owing to a perfect lock occlusion, as shown in Figs. 694 and 695. The cutting edges of the front teeth have been stained to imitate the effect of tobacco upon the denuded dentine. The rugæ in the cut show a direct transfer from the model upon which the case was mounted.

The modifications which can readily be made in the expression of a set of teeth by shading, by grinding, and in mounting will surprise any one who has not given thought to the subject and experimented in this direction. Fig. 697 illustrates what is considered a beautiful set of continuous-gum teeth, of what may be called the English type, but capable of wide modification when of different shades and ground and mounted with reference to different ages and other individual character-

istics. The teeth are represented in the shape given to them by the mould. Fig. 698 shows the same teeth altered in expression by grinding

FIG. 696.



the cutting edges and squaring the mesial surfaces, which gives an appearance of age. This effect can be carried to a lesser or greater degree to suit the individual case.

FIG. 697.

FIG. 698.

Fig. 699 is a mounted set from the same mould, and may represent a patient, say, of the Anglo-Saxon type twenty-five years of age—a broad, full, well-developed mouth, clear-cut, well-formed teeth, with no enamel-blemishes. In this set has been retained as nearly as possible the natural formation of the teeth as they come from the mould, to show a young mouth and to make the variations in the cases which are to follow more distinctive. The superior centrals are thrown out slightly by the underlapping of the laterals. A slight irregularity of the four inferior front teeth has been made merely to avoid conventional uniformity and to disarm suspicion of artificiality. The jaws are shown a little apart in order to display the cutting edges more

clearly, as illustrated by Figs. 700, 701, 702, 703, and 704. They represent teeth from the same mould as those of Fig. 697, and have been arranged to carry out this series. These cases show the wide range which this one set of teeth is capable of being made to cover. Fig. 700 may illustrate the mouth of an old gentleman, robust and vigorous, florid face. The shading of this set of teeth for such a case is perfect; the abrasions are well marked, and the irregularity of the lower incisors is exceedingly natural. Fig. 701, a side view of the same case, shows the irregularity even better than the front view.

Fig. 699.

The loss of the left superior first bicuspid, creating the gap so frequently seen at this point in natural dentures, gives greater prominence to the cuspid, making it seem more indicative than before of strong animal passions. Fig. 702 is a palatal view of the same case.

Fig. 700.

Fig. 703 shows the mouth of an individual past middle life and the recession of the gums so often seen. The effect produced by the abrasion of the lower incisors and the separation of the centrals is exceedingly life-like, and well calculated to convey the impression of original ownership. Fig. 704 is a side view of the same case.

Fig. 701.

No one who will take the trouble to compare, or rather to contrast, Figs. 699, 700, and 703, remembering that these three sets of teeth, so radically different from one another, were made from teeth out of the

same mould, can fail to be impressed with the thought that the blame for the "picket-fence" conventional dentures generally seen in the mouths of their wearers is not always to be laid at the door of the manufacturer, but is often to be attributed to the want of artistic taste in those who mount and arrange them.

Fig. 702.

Figs. 705 and 706 present practical cases. They have been chosen on account of their extreme variation of characteristics, as representative of cases which frequently give much trouble and annoyance to the practitioner in the effort to secure as natural effects as he and his patients would desire.

Fig. 705 is taken from the models to show the close articulation resulting from the prominent alveolar ridges left by the recent extraction of the teeth. The mouth is inclined toward what is termed the lambdoid type—V-shaped arch, etc.

Fig. 703.

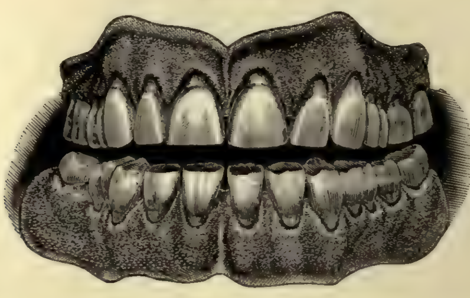


Fig. 704.

Fig. 706 represents a front view of this set of teeth. It is important to ascertain, by questioning the patient without letting the object appear,

as to what the natural teeth were like, regular or otherwise, to assist the judgment which may be formed from the face, models, etc. Acting on the

Fig. 705.

Fig. 706.

information received and the idea formed of the facial requirements, there is a slight protrusion of the upper front teeth, a slight irregularity in the lower teeth, and a little overlapping of the centrals of the upper set by the laterals. The teeth are short and full, the six front ones being set directly on to the gums.

Fig. 707 gives a side view of the same, showing more clearly why it is necessary to mount the upper front teeth directly upon the gums: First, because the recent extraction left prominent alveolar ridges: second, because the patient has a short, thick upper lip, which would have been made more prominent, rigid, and unnatural-looking had the teeth been set outside the arch; third, had the lower teeth been thrown out sufficiently to meet the upper teeth, if these were mounted outside of the arch the mouth would have presented the appearance resembling that of an herbivorous animal, and, moreover, such an arrangement would have made it impossible to hold the plates in position during mastication.

Fig. 707.

Fig. 708 shows the models of a patient of advanced age, in which there is exactly an opposite condition of things from the preceding one —a rather full and very flat jaw, the alveolar ridges having been much absorbed, and a wide articulation being required to restore the harmony of the features.

Fig. 709 is a front view of the set made for this case. It is peculiar,

for many reasons. The plate was made of gold, the teeth attached with celluloid. The teeth are of medium length, some of them represented as

Fig. 708.

Fig. 709.

slightly exposed at the roots, especially the cuspids. A slight show of irregularity is made by allowing the laterals to rest behind the centrals. The cuspids are prominent and have rather a broad front. The buccal prominences were meant to slightly fill out the cheeks and to protect the soft parts from the springs.

Fig. 710 presents a three-quarter view of the same case, showing the articulation to be on the cutting edges of the incisors, in imitation of the natural teeth. To give a more natural appearance, the second superior bicuspid was left out, indicating a lapse of time since its loss by representing the space as partially closed up by the moving forward of the molars. In the lower jaw both bicuspids are missing on the left side, while the molars have moved forward until stopped by the superior first bicuspids; the lower cuspid was unable to move backward by being locked between the superior cuspid and lateral. This illustration shows another view of the "plumpers" and springs.

Fig. 710.

Fig. 711 shows partly the reason for the use of springs; the mouth being very flat (see Fig. 708), hard, and dry, afforded little opportunity for a plate to be held by atmospheric pressure. The patient was nauseated by the slightest touch upon the posterior portion of the hard palate, and too irritable to allow of any efforts to overcome its susceptibility. Being an epicurean, and thoroughly convinced that with an ordinary plate he could not taste his food, some other method had to be resorted to. The old method of constructing a very narrow plate for the upper ridge, sustained by spiral springs, was therefore adopted—a happy expedient in this case. The engravings show the

manner of applying the springs, and the shields for protecting the soft parts from irritation by them.

In Fig. 711 are seen the abraded cutting edges stained, the irregularities, the spaces left by the lost teeth, the relation of the teeth to each other, and the shapes of the plates. The lower molars are leaning toward each other across the tongue, the incisors inclined forward, etc.—all tending to make the case as natural and comfortable in the mouth as possible.

Fig. 711.

The causes of spaces between the natural teeth may here be briefly considered. In Dr. James W. White's little work entitled *The Mouth and the Teeth*, p. 41, the statement is made that "the teeth in man are arranged in close contact, without intervening spaces, affording each other mutual support after the manner of staves in a barrel. Being set without interspaces on a curved line, it follows that their outer surfaces are wider than the inner." If this is correct (as in ninety-cases out of a hundred it is), why should dentists and manufacturers persist in producing what is unnatural and disfiguring when correct models are so easily procured?

Fig. 712.

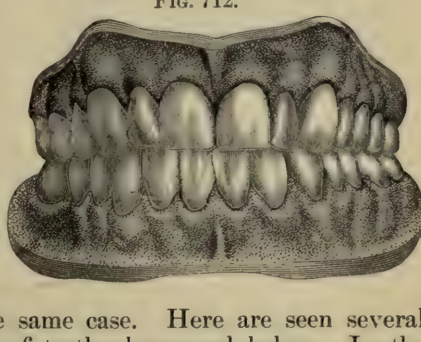


Fig. 712 is a front view of a case designed to show the causes for interspaces, though this particular cut does not do so. The teeth are full and rounded, presenting a pleasing effect. The laterals lapping over the centrals are broad, accounting in part for their irregularity.

Fig. 713 is a side view of the same case. Here are seen several spaces developed through the loss of teeth above and below. In the superior maxilla the second bicuspid is absent, while the first and second molars have moved forward and the first bicuspid settled backward, adjusting themselves to easy occlusion, and nearly filling up the space left by the lost tooth, but at the same time creating new interspaces between the first bicuspid and cuspid and first and second molars. The lateral is prevented from working backward by the inferior cuspid. In the lower maxilla the first molar has been lost, the second has moved slightly forward, locking between the superior first and second molars, while the second inferior bicuspid has settled backward—probably from the force of mastication—occluding comfortably with the first superior

bicuspid and molar, but leaving another space between the first and second inferior bicuspids. In this mouth are both crowding and interspaces, and causes for both.

FIG. 713.

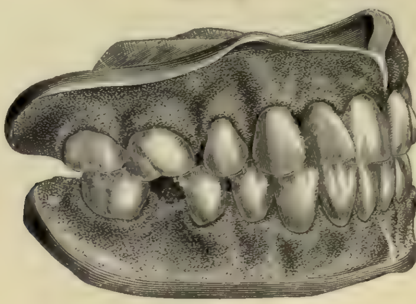
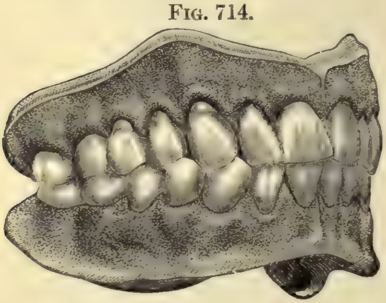


Fig. 714 illustrates another frequent cause of interspaces—namely, locking of the teeth through occlusion. In this case nearly all the teeth bear firmly against each other for support, and, as shown in the cut, have almost a perfect occlusion from the cuspids back, though the point claiming special attention is the interspaces on either side of the superior cuspid, which is slightly turned on its axis and is locked between the cusps of the cuspid and first bicuspid of the lower maxilla, precluding a possibility of its movement either forward or backward without artificial interference. The first superior bicuspid cannot come forward, owing to its nice occlusion with the first and second inferior bicuspids; the superior lateral cannot move backward, although crowded and overlapping the central, as it is forced forward and retained in position by the cusp of the inferior cuspid. So here, again, the interspaces are caused by malposition.

FIG. 714.



The art of arranging artificial teeth as at present practised in this country is governed by the irregularities found in nature as results of the amalgamation of races. In many cases there is likely to be an inequality of development between the upper and lower maxillary bones, one jaw partaking of the characteristics of the father, the other of the mother. The result generally is overcrowding or irregularity, but sometimes cases are

FIG. 715.

found such as shown in Fig. 715. Here is a well-developed inferior dental arch, with proportionately well-developed teeth, characteristic of one parent, while in the superior dental arch the teeth resemble those possessed by the other parent, and are too small in proportion to the size of the jaw. The result is interspaces between nearly all of the teeth in the superior dental arch.

Fig. 716 is a side view, displaying these defects, the cusps of the superior falling in between those of the inferior teeth.

The few preceding cuts serve to illustrate how well zylonite or celluloid is adapted to meet the requirements as a base for artificial dentures, and it must be admitted that, so far as experience has gone, this material in combination with single teeth and mounted on metallic lining has given as much satisfaction as any other base. No opportunity of testing the zylonite under the microscope, as has been done with celluloid proper, has presented, but sufficient has been learned of its qualities to indicate that it is superior in every particular as the two are now presented to the profession. The color is better, and always uniform: celluloid is not uniform in color, sometimes running into a very objectionable greenish tinge. By comparing the two it will be noticed that there is a translucency or depth to the surface of the zylonite not found on the celluloid, which has a thoroughly dead surface. The celluloid has a tendency to scale or disintegrate unless the blanks are very carefully selected. This is not the case with zylonite; nor has any tendency to soften, or "wash out," from about the pins, as observed with celluloid.

Fig. 716.

The zylonite company, having benefited by the experience of other manufacturers of this material, has attained an excellence in the manufacture—first, of the dinitro-cellulose, which is so delicate a process; secondly, in the perfect admixture of the necessary ingredients to make the compound, resulting in an article that is uniform under all vicissitudes of weather, possessing great resiliency, beauty, and diminished inflammability.

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CHAPTER XVII.

THE TEMPERAMENTS AND THE TEMPERAMENTAL CHARACTERISTICS OF THE TEETH IN RELATION TO DENTAL PROSTHESIS.

BY ALTON HOWARD THOMPSON, D. D. S.

"TEMPERAMENT," says Dr. D. H. Jacque,[1] "is a constitutional condition produced by the mixing in different proportions of various physical elements. The functions of life are not performed in all persons with the same degree of force or rapidity. These differences are the results and indications of what is called *temperament*, the *corpori habitus* of the ancients. It is by the combination of these constitutional elements in various proportions that the body is *tempered*, the predominating element determining the prevailing temper or temperament, and the others the modifications which may be present. A particular temperament is the result of the preponderance of one of these elements over all the others. The ancients, assuming the possibility of these elements all being equal in a given case, were accustomed to speak of the *temperamentum temperatum*, the temperable, harmonious, or balanced temperament; but it is scarcely to be conceived of a single instance in the human species in which there is perfect equilibrium in all parts, although near approach to this condition may be found.

"It is evident that in an ultimate analysis the temperaments must be as numerous as the individuals of the human race—no two persons, probably, having precisely the same physical organization or the same proportion of each elemental ingredient of the compound structure in which each lives, moves, and has a being.

"It is essential for practical purposes, therefore, to reduce these numberless individual peculiarities to their simplest elements, and group together such persons as resemble each other in certain particulars or who have a similar organization. To this end writers on the subject have generally considered the temperaments under from three to five general heads, which are subdivided."

The ancients first observed the differences of bodily action and functional activity which distinguish individuals, and four temperaments, founded on constitutional conditions, were recognized and described by Hippocrates. The temperaments, according to his theory, depended upon what were then known as the four primary components of the human body—the blood, the phlegm, the "yellow bile, and the black bile." Persons in whom the blood predominates, he said, have the *sanguine temperament;* if phlegm be in excess, the *phlegmatic temperament;* if yellow bile, the *choleric;* and if black is in excess, the *melancholic temperament.* This was the original classification, and has influenced writers and students more or less in all systems of description down to our own times.

"The doctrines of Hippocrates and the ancient physicians were often

[1] *The Temperaments, etc.*, Dr. D. H. Jacque, Fowler & Wells, 1878, p. 30 *et seq.*

discussed, but never greatly modified, until the advances in physiology and humoral pathology in comparatively recent times rendered their defects too obvious to be overlooked; and even then the same classification and general nomenclature were generally adhered to. At a later date Dr. Gregory added to the four temperaments of the ancients a fifth, which he called the nervous temperament. The ancients, and the modern writers following them, were accustomed to look upon the temperaments from a merely physiological or pathological standpoint, and but little was said or known of the reciprocal influences of mental and physical qualities and states."

Dr. Spurzheim's classification is that upon which later systems were founded: (1) the lymphatic; (2) the sanguine; (3) the bilious; and (4) the nervous temperaments, which are determined by the presence of the lymphatic, the sanguine, the bilious, or nervous elements. Some of these Dr. Jacque considers more or less pathological, three only being perfectly normal bodily conditions; and two, the lymphatic and the nervous, are pathological or diseased. But they are none the less real, though being aberrant or unnatural. Such states of the constitution are far too common to be ignored, and must be taken into account. Dr. Jacque proposed a later classification (in which he eliminated the pathological and abnormal conditions) which he thought was simpler and more natural. He included under three heads all the various normal conditions. These he named—

(1) The motive or mechanical system;
(2) The vital or nutritive system; and
(3) The mental or nervous system.

These are divided into several branches, which include all the organs and dominate all the functions of the physical man. . . . . "First, the bony framework bound together by ligaments and overlaid with bundles of muscular fibres, by means of which its parts are moved and locomotion produced; second, the vital or nutritive system, whose principal masses lie in the chest and abdomen, and consist of the lymphatics, blood-vessels, and glands performing the functions of digestion, secretion, circulation, etc; and third, the mental or nervous system, having its principal seat in the cranium, but extending itself in ramifications through every part of the body and furnishing the medium of sensation and volition."

A classification may be adopted which will include these under the older headings, with the addition of the pathological temperaments, as he calls them, which are equally important and entitled to study and consideration.

For a diagnosis of the temperaments it will be best to present their leading characteristics in tabulated form, for convenience of reference. The groupings of indications under various headings will facilitate the study of an individual under observation. The indications are those given by Spurzheim, amplified by Dr. Jacque's wise criticisms and learned observations.

To this is added a table of Dr. Jacque's later system of classification, by way of illustration and comparison.

After that a table of the ordinary combinations, and then tables of the temperamental characteristics of the teeth.

TABLE I.—*The Indications for Diagnosis of the Temperaments.*

	Basis.	Stature.	Osseous development.	Muscular development.	Contour.	Circulation.	Face and features.	Skin and complexion.	Hair.	Eyes.
(1) The lymphatic temperament.	The predominance of the lymphatic system.	Rather above medium, but sometimes below.	Coarse and loose; articulations voluminous, but badly formed; extremities large and ugly.	Soft and flabby, and act with difficulty and slowness.	Fulness of body, sometimes amounting to corpulence, and without grace or beauty.	Heart sluggish; pulse slow and feeble; blood thin, pale, and lymph-like.	Face full, heavy, and expressionless; cheeks pendant; lips thick, etc.	Skin a dull leaden white, faded or yellowish, and generally cold and moist.	Fine and silky, but lustreless; a pale blonde or sometimes reddish or flaxen.	Pale blue or gray; faded and expressionless.
(2) The sanguine temperament (the xanthro-vital of Dr. Jacque).	The predominance of the arterial circulatory system, and of the lungs and capillary vessels generally.	Generally above the medium, sometimes quite tall.	Well-proportioned; articulations light and slender; the extremities indicating grace and activity.	The muscles finely moulded for elegance and suppleness.	Slight and graceful, or full, but not heavy.	Heart vigorous, the arterial flow active and bounding; the blood red and rich.	The face inclined to roundness; the lips full and red; the features well marked and full of vivacity and expression.	The skin fine, soft, and transparent; the plexion fresh and ruddy.	The hair blond, red, or chestnut, rarely dark or black.	The eyes blue, brilliant, and expressive.
(3) The bilious temperament (the motive temperament of Dr. Jacque).	The predominating organ is the liver, which influences the whole system.	Medium or tall.	Angular and rugged: rough articulations and large extremities.	Strongly defined; cord-like and hard; the movements slow and deliberate.	Angular and rugged, massive and ungraceful.	The heart slow, the venous circulation predominating over the arterial.	Harsh and angular; severely expressive.	Skin coarse and dry; complexion olive, tawny, or dull.	Hair coarse, dark (often black), and abundant.	Eyes black or brown, small and piercing.
(4) The nervous or mental temperament.	The excessive development and morbid activity of the brain and nervous system.	Below the medium; slight and wiry.	Small frame; the bones light and thin; the skull very full over the large brain.	Small muscles; thin, strong, and nervously active, and given to spasmodic efforts.	Thin and habitually emaciated.	Heart nervously active; blood thin, pale, and innutritious.	Sharp and thin: expression nervously animated.	Fine and pale, sometimes sallow.	Fine, light, and soft.	Light gray or blue, restless, and often morbidly brilliant.

TABLE II.—*Dr. Jacque's Anatomical Classification of the Temperaments.*

	Basis.	Stature.	Osseous development.	Muscular development.	Contours.	Circulation.	Face and Features.	Skin and complexion.	Hair.	Eyes.
(1) Motive temperament.	Bony and muscular framework.	Tall and striking, with fine carriage.	Bones large and long; prominent articulations.	Hard, strong muscles, with large attachments.	Angular and sharp; shoulders broad; limbs long; extremities large.	Full and strong; heart strong and active.	Cheek-bones high; the features generally sharp and prominent.	Two varieties—one dark and swarthy, the other light and florid.	Brown or black in dark type — light, blonde, or red in light type.	Dark or brown in dark type—blue, gray, or hazel in light type.
(2) The vital temperament.	The predominance of the nutritive system.	Above medium.	Small but well developed.	Strong and graceful.	Breadth and thickness of body; limbs small.	Heart strong, blood red and active.	Face full and round; the features well marked.	Light and rosy or dark and olive (in the two varieties).	Flaxen, yellow, or auburn, or brown or dark.	Blue and gray, or brown and dark.
(3) The mental temperament.	The excessive development of the brain and nervous system.	Medium or below medium.	Frame slight; head very large.	Small, but well formed; rapid in movement.	Body small and usually ill-formed.	Heart nervously active; blood pale and thin.	Oval face; high forehead; delicately cut, if not sharp features.	Delicate, transparent skin, or sallow and leathery.	Fine, soft hair, light in color, and not abundant.	Gray or hazel, and brilliant.

TABLE III.—*The Binary Temperamental Compounds.*

	Basis.	Stature.	Osseous development.	Muscular development.	Contours.	Circulation.	Face and features.	Skin and complexion.	Hair.	Eyes.
(1) Sanguo-bilious.	The combining of arterial and venous or biliary elements, with predominance of the first.	Above average size.	Strong and heavy; head square; jaws large.	Full and well-developed, but not graceful.	Disposed to irregularity; mostly sharp and angular.	Full in both arterial and venous systems; heart strong and active.	Rather angular; high cheek-bones; nose large; lips full and large.	Rather smooth; little color, or dark and yellowish.	Black or dark, coarse or curly; not usually abundant; beard full; eyebrows straight.	Full, and usually dark and lustrous.
(2) Bilio-sanguine.	Slight predominance of the bilious element, with sanguine modification.	Much above average, of tall stature.	Wide and strong, bones large; articulation full.	Knotty and hard; modified by sanguine roundness.	Broad shoulders; full chest; and strong, round limbs.	Strong and dark; heart quick and full.	Cheeks full; forehead large; jaws large and round; chin heavy; mouth large; lips full and red.	Skin smooth; soft and creamy, varying to rosy olive.	Dark, wavy, and luxuriant, and fine in texture; beard full; eyebrows arched.	Eyes dark, large, lustrous, and expressive; sometimes deep blue.
(3) Lymphatico-bilious.	Lymphatic and bilious elements, lymphatic predominating.	Decidedly above average size.	Rather coarse and irregular; articulations large.	Medium and well-developed.	Well-rounded and inclined to fulness in women.	Full, but not red or vigorous; heart irregular.	Face full; forehead large; jaws and chin round; mouth large; lips thin and bluish.	Rather rough and and dark-colored, with tendency to ephelides, moles, etc.	Hair and beard dark, full, and wavy; eyebrows straight and heavy.	Eyes dark-brown or gray.
(4) Bilio-lymphatic.	Bilious and lymphatic elements, bilious predominating.	Above average size.	Large and coarse, without strength or grace.	Irregular, or full, but weak.	Round and soft, inclined to flabbiness.	Weak and thin, or dark; heart irregular.	Cheek-bones large; forehead full; jaws large and square; mouth large; lips thin.	Dark, pallid, and opaque.	Dark, moist, straight; beard heavy and dark; eyebrows straight	Large, dark, or dark gray; weak and expressionless.
(5) Nervo-bilious.	Nervous and bilious elements, the former predominating.	Average or irregular stature.	Bones irregular, weak, and angular.	Wiry and cord-like; or may be rather full and strong.	Small, irregular, and shapeless.	Thin and dark blood; heart irregular and weak, or active and cord-like pulse.	High cheek-bones; forehead large; jaws small, and chin small and pointed.	Inclined to dark, and often sallow and pallid.	Dark; decidedly curly; beard sparse and irregular.	Dark-brown; rather expressive.

(6) Bilio-nervous.	Bilious and nervous elements, the former predominating.	Less than average size.	Small, weak, and irregular.	Small, weak, and poorly developed.	Slight and small, or large and coarse.	Dark and weak; heart active.	Cheek-bones high and prominent; lower face thin and contracted.	Dark and subject to freckles.	Ranges from dark-brown to dark red; beard dark to red; eyebrows arched.	Small; hazel to light, or dark brown to black.
(7) Nervo-sanguine.	Nervous and sanguine elements, the nervous predominating.	More than average size, as a rule.	Strong and shapely; articulations finely proportioned.	Full and well-shaped; strong and graceful in movement.	Well-moulded, fine limbs and broad shoulders.	Blood red and bounding; heart active.	Cheeks full; forehead round; jaws and chin well shaped.	Fair, clear, and pink-toned.	Hair and beard sandy to red, full and wavy; eyebrows light and arched.	Large; light hazel or clear blue
(8) Sanguo-nervous.	Sanguine and nervous elements, the sanguine predominating.	Rather less than average size.	Small and light; articulations small.	Small, but graceful and vigorous.	Rather slight, but sometimes full and rounded.	Blood full, but light-colored; heart active.	Forehead high and broad; cheek-bones prominent; lower face rather thin; chin small.	Fair and smooth, with tendency to ruddiness.	Light and curly, but fine, with tendency to baldness; beard scanty; eyebrows light and arched.	Blue or gray; full; large and expressive.
(9) Lymphatico-sanguine.	Lymphatic and sanguine elements, the first predominating.	More than average height.	Bones good and well-developed; articulations well-shaped.	Fairly well-developed, and rounded; rather soft and medium in activity.	Round and shapely; full and graceful, but disposed to obesity.	Good medium as to blood, color, and heart action.	Face round; cheeks full; jaws large; mouth shapely, and lips full and red.	Very smooth and fair, pinkish, inclined to florid; sometimes freckled.	Blond or light chestnut, inclined to curl; beard medium; eyebrows dark and arched.	Light gray or blue; large and full.
(10) Sanguino-lymphatic.	Sanguine and lymphatic, the sanguine predominating.	Above average in size; inclined to be tall.	Bones long and well-developed; articulations shapely.	Full, but not hard, active, but not enduring.	Inclined to irregular fulness, often corpulent.	Full, red, and active; heart strong.	Large and full; forehead high; jaws and chin round and full; lips full.	Soft and smooth; ivory-white to pink complexion.	Dark to light chestnut, sometimes luxuriant; beard full.	Large, light-colored; with placid expression.
(11) Lymphatico-nervous.	Lymphatic and nervous elements, the first predominating.	Stature very irregular, but usually above average.	Usually large, with courseness; articulations full, but ill-shaped.	Rather full, but moderately strong and active.	Usually full and round, but irregular.	Blood thin and full; heart weak; pulse irregular.	Face round; forehead large; cheeks full; lips thick.	Dark to light; usually pallid, with little color.	Variable in color; slightly wavy; beard light.	Variable, light or dark, sometimes light hair with dark eyes, or *vice versâ.*
(12) Nervo-lymphatic.	Nervous and lymphatic elements, the nervous predominating.	Average size or below.	Bones moderate in size; of low structure.	Low development, full but weak.	Round and soft, or thin and flabby.	Blood light and thin; heart weak and nervous.	Face thin, or full and heavy; forehead high and bulging; mouth weak; lips thin.	Light, pallid, coarse skin, inclined to blotches.	Light in color; slight in quantity; eyebrows straight	Dull, grayish; inclined to green or hazel in color.

TABLE IV.—*The Temperamental Characteristics of the Teeth.*

Basal temperaments.	Size.	Shape.	Color.	Texture.	Enamel.	Cusps and edges.	Arrangement.	Articulation.	Arch.	Vault.	Gums.	Rugæ.
(1) Bilious temperament.	Large and strong.	Conical; long, and angular.	Strong; bronze yellow.	Dense and hard.	Rough and strong; often transverse lines.	Square and heavy.	Close set and regular.	Firm, close, and well-locked; plane much curved.	Large, square, with prominent canines.	High and square.	Orange-red; dense; margins heavy.	Heavy, square, and rugged.
(2) Sanguine temperament.	Medium in size.	Well-proportioned; curved and rounded.	Cream-yellow; darker at neck.	Rather dense and strong.	Smooth, lustrous, and brilliant.	Rounded and well-shaped.	Rather close and regular.	Moderately firm and close; wears to square bite; plane curved.	Round; square; finely shaped.	Round and arched.	Red or pink; health-line clear; full-arched margins.	Numerous and graceful in outline; well-rounded.
(3) Nervous temperament.	Small or medium.	Long, conical, and rounded.	Pearl-blue or gray.	Average density or soft.	Smooth, polished, and translucent.	Long, thin, sharp, and transparent.	Irregular; disposed to lapping and malposition.	Long and penetrating, but irregular.	Round; V-shape; of "Gothic arch."	High and Gothic in shape.	Pale and thin margins; delicate and shapely.	Small and sparse.
(4) Lymphatic temperament.	Large and coarse.	Ill-shaped; broad and flat.	Pallid, opaque, muddy, or yellow.	Brittle and chalky.	Coarse, opaque, and dead finish.	Poorly defined; coarse and blunt.	Not close, but regular.	Loose, flat, and irregular; plane flat.	Large and round; "horseshoe" arch.	Low and flat.	Pale and soft; margins thick and undefined.	Sparse and flat.

The Binary Temperaments.

The basal temperaments are never found alone, but usually in combination with other elements which modify the original base. The compounds are generally binary—*i. e.* a base with one prominent modifying factor. This combination is called a *binary temperament*. They are named in accordance with the base and the most important modifying element. Thus, the sanguino-bilious means that the sanguine temperament is most prominent, and the modifying element is the bilious. Other elements may be present, but these cannot always be diagnosed with certainty.

The table of binary compounds (on page 582) is based on the indications given by Dr. Ives.[1]

By comparison of this table with the preceding one of temperamental indications the proper teeth can be readily selected ; *i. e.* having diagnosed the binary compound of the person under observation, turn to the table of temperamental characteristics of the teeth which accompany that compound, and select the proper mould and color, and arrange them according to the indications given. This will give a more artistic appearance to prosthetic work than it usually attains. As Dr. J. W. White said :[1] " What is needed is such an appreciation of the law of correspondence that the dentist can cipher out, as by the rule of three, the character of teeth required in the case of an edentulous mouth with the same precision that the comparative anatomist can from a single bone indicate the anatomical structure of the animal to which it belonged. The probability is that in many, perhaps in most, of the cases of artificial dentures the fault is not in the carelessness or indifference of the dentist, but in his failure to recognize the requirements of temperaments. A certain family resemblance to each other in a set of teeth is considered essential, but the adaptability of the set as a whole to a given case should be esteemed of even greater importance. A set of teeth in which not only the relative length and breadth, but every line and curve, characterizes it as belonging to a certain temperament may be made of a color never found in nature connected with such forms. Thus are seen repeatedly such incongruities as the association of the massive tooth of the bilious temperament with the pearl-blue color of the nervous temperament, and the long, narrow tooth of the nervous temperament with the bronze-yellow color never seen in any but those of a bilious temperament—showing that the laws of correspondence had not been sufficiently observed. The first study of the dentist when proposing to replace a lost denture should be how to restore the natural appearance of his patient, and this can only be effected through an appreciation of the temperamental characteristics and the law of correspondence or harmony. Age and sex may somewhat modify the requirements in a given case, but the basal fact on which he should proceed is temperament. A failure to recognize its demands will result in failure from an æsthetic standpoint. A knowledge of the distinguishing characteristics of the various temperaments and the style of teeth which conform to nature's type in the physical organization marks the difference between the dental mechanic and the dental artist."

[1] *Amer. Syst. of Dent.*

TABLE V.—*The Temperamental Characteristics of the Teeth.*

Binary compounds.	Size.	Shape.	Color.	Texture.	Enamel.	Cusps and edges.	Arrangement.	Articulation.	Arch.	Vault.	Gums.	Rugæ.
(1) Sanguo-bilious.	Large and very strong.	Large and full-formed; angles undefined.	Dark yellow.	Strong and of good quality.	Rather opaque and rough.	Strong, heavy, and well-defined.	Close set and disposed to malposition.	Close and well-locked; plane curved.	Round-square.	Round and high.	Deep-red; margins well defined.	Heavy, numerous, and angular.
(2) Bilio-sanguine.	Medium or large.	Full and square; rather angular.	Rich yellow cream-color.	Dense and good quality.	Rather smooth, but sometimes good.	Finely shaped and full.	Regular and close set.	Close and well-locked; plane curved.	Round-square, or square.	High and square arch.	Red or pink; margins sharp and well-defined.	Well-marked and numerous.
(3) Lymphatico-bilious.	Large and coarse.	Large and irregular in form.	Dark-yellow or muddy.	Mixture of flinty and chalky.	Rough, dull, and opaque.	Thick and short.	Loose, but regular.	Loose and flat; the plane level.	Round, or round-square.	Rather low, but arched.	Red and soft; margins ill-defined.	Sparse and shapeless.
(4) Bilio-lymphatic.	Usually large.	Square and heavy, angles sharp.	Yellowish, but clear.	Soft and brittle.	Rather smooth and disposed to cross lines.	Short, thick, and heavy.	More or less spaced, but regular.	Rather firm, but flat plane.	Rather square.	Arched and low.	Pale to red; margins well-marked.	Close set, but narrow.
(5) Nervo-bilious-	Variable —large to small.	Broad or long; sometimes "bell-crowned."	Yellowish and bluish in varying combinations.	Rather soft and frail.	Smooth and dull, or translucent.	Long or square.	Close, but disposed to torsion and malposition.	Long and deep, but not close; plane uneven.	Square or V-shaped; often abnormal.	High and square or contracted.	Pale and thin; margins ill-defined.	Thin and very tortuous.
(6) Bilio-nervous.	Medium large.	Long and often narrow.	Bluish to yellow.	Rather soft and weak.	Smooth but irregular surface.	Long and rather translucent.	Close, and disposed to malposition.	Deep and close; plane curved.	Square and narrow; often abnormal.	High and tends to Gothic form.	Red or pale; margins thick.	Large, deep, and well-curved

(7) Nervo-sanguine.	Average in size.	Fine shape; rather long.	Rich cream-color to bluish.	Strong and excellent in quality.	Smooth, brilliant, and strong.	Well-marked and shapely.	Close and shapely, but strongly disposed to malposition.	Close, deep, and firm; the plane curved.	Round V; fine in outline.	Medium and well-arched.	Deep pink and clear; margin well-marked; festoons graceful.	Long and well-marked; numerous and graceful.
(8) Sanguino-nervous.	Average size.	Well shaped and moulded; narrow necks.	Bluish cream-color.	Good, but dentine sensitive.	Smooth, bright, and translucent.	Good and shapely.	Well set, but inclined to crowding.	Close and deep; plane irregular.	Round V; good shape.	High and well-arched.	Pink and clear; margins sharp.	Numerous and sharply defined.
(9) Lymphatico-sanguine.	More than average.	Large and round.	Grayish-cream.	Soft and poor in quality.	Smooth and clear.	Good shape; round and full.	Well arranged, roomy, and often spaced.	Close, but shallow, and flat plane.	Round or round-square.	Flat or round.	Transparent, pink; margins loose.	Low, flat, and sparse.
(10) Sanguo-lymphatic.	Large.	Broad and round; angles rounded.	Creamy-gray.	Fairly good and strong.	Smooth, but rather opaque.	Round, but well-defined.	Well-arranged, but disposed to spacing.	Flat, but regular.	Round or round-square.	Well-arched, but low.	Clear pink; margins full.	Numerous and well marked.
(11) Lymphatico-nervous.	Below average.	Well-shaped, but irregular.	Grayish-blue.	Soft and sensitive.	Smooth and clear, or dull and rough.	Usually sharp and well-shaped.	Rather irregular, and disposed to crowding.	Loose and irregular; plane flat.	Round or round V; much subject to abnormal forms.	High and narrow.	Pale and soft; margins thin.	Low and ill-shaped.
(12) Nervo-lymphatic.	Average size.	Good shape and length.	Bluish-gray.	Soft, weak, chalky, and sensitive.	Smooth, soft, and translucent.	Long and sharp, but weak.	Close, but uneven plane.	Long and deep, but irregular.	V-shape or abnormal.	High and irregular.	Soft and light-colored; margins ill-defined.	Soft and irregular; sometimes quite low.

CHAPTER XVIII.

ARTIFICIAL CROWNS.

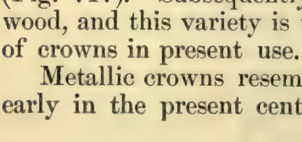
BY H. H. BURCHARD, M. D., D. D. S.

WHEN the crowns of teeth have suffered such extensive loss of substance that restoration by means of filling material is inadvisable, the restoration is an operation of prosthetic dentistry.

The term "artificial crown," as technically applied, includes only such devices as are made in the dental laboratory and subsequently set as a single piece upon a prepared root or remnant of tooth. The pieces known as "partial crowns" are also included in this category.

The first example of crown substitution, mounted according to the principles governing contemporary crown operations, was the setting of a crown of a natural tooth upon a prepared root, the support being afforded by a post extending from the enlarged pulp-chamber of such a crown into the enlarged canal of the root.

FIG. 717.



The mechanical principle involved in this mode of support has had constant application. The next variety of crown employed is that of porcelain, the post support being, as in the preceding form, a hickory post (Fig. 717). Subsequently metallic posts were substituted for those of wood, and this variety is the typal form of one of the two great classes of crowns in present use.

Metallic crowns resembling those of the present day were employed early in the present century.

CLASSES OF CROWNS.

All of the varieties of artificial crowns may be divided into two great classes, according to their means and modes of support. The first class

FIG. 718.

A B C D

FIG. 719.

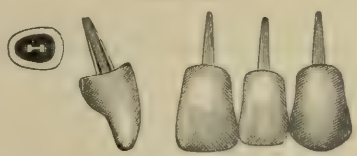
A B

includes all of those crowns which depend for fixation upon a post anchored in an enlarged pulp-canal (Fig. 718). The second class in-

cludes those which have their retention secured by means of a continuous band encircling the neck of the root (Fig. 719).

Class 1 is subdivided into two orders: First, those in which the post is an integral part of the artificial crown, being baked in it or soldered to it (Fig. 718, *A* and *B*); second, those in which the post is firmly

FIG. 720.



Class 1, Order 1.

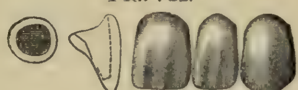
anchored in the pulp-canal, as a primary measure, and upon this support the crown itself is fixed as a second operation (Figs. 718, *C*–721, 722).

A sub-order includes the collar and post crown (Fig. 718, *D*), the band encircling the root acting as a subsidiary support to the root, protecting it against fracture, the post being the retentive device proper.

FIG. 721.

Class 1, Order 2.

FIG. 722.



Class 1, Order 2.

All of the artificial crowns in present use will be found to be a variety or some modification of one of these classes.

Each variety is designed and fitted to meet definite indications, and the application and choice of variety are determined by the anatomical, physiological, and pathological condition of the root to be crowned and, it may be, of the surrounding parts.

ANATOMICAL RELATIONS.

The first consideration is the position of the root to be crowned; and the second, its form. Its position includes the class of tooth, whether it be an incisor, cuspid, bicuspid, or molar; next, its relative position to its neighbors and to its antagonists, and what will be the relations of the artificial crown in these particulars.

Each class of tooth has a definite office to perform, and there is involved in the performance of its function an amount and variety of stress governed by the position of the tooth—*i. e.* the class to which it belongs. This demands in the supporting structures of the crown and root sufficient resistance to secure the integrity of the crown and root in the performance of their normal functions.

Incisors by their positions and forms are designed to receive and resist stress in one direction, that tending to force them outward.

Cuspids in their normal relations receive stress in two directions: two forces act at an angle upon the axis of the tooth, and the resultant of these forces is a line outward.

Bicuspids are subjected to three stresses—vertical, outward, and inward; the relative amounts of stress are in the order given. The amount of the outward and inward stress is governed primarily by the lengths of the buccal and palatal or lingual cusps; the vertical stress, by the area of the occlusion surface.

Molars.—The vertical stress is greatest, and in the direct ratio of the extent of masticating surfaces; the lateral stress is governed by the lengths of the cusps.

Artificial crowns should be made of varieties to meet and resist the several directions of stress.

The line of greatest mechanical resistance in any root is in its vertical axis, and is the only line of stress which does not tend to mechanically displace the tooth. As to the vital resistance of a root, this rule is but partially true, for roots appear to rebel against stress in any other direction than that due to their normal anatomical positions.

In normal occlusion the stress upon any individual tooth is lessened or modified by the occlusion of the other teeth of a denture, so that the conditions of any tooth as part of a denture are not those of the same tooth standing alone. For example, the incisors normally receive a stress which ceases as soon as the molars and bicuspids are in perfect contact; in the absence of these latter teeth the entire force of occlusion falls upon the incisors, and they are unduly strained.

The incisors receiving stress in a direction tending to their outward displacement, the indication in crowning is to provide a fixture which shall best resist this direction of stress. Evidently, the device would be a rigid rod extending through the longitudinal axis of the root; hence, post crowns are selected for incisors.

The condition of the root, as discussed later, may demand modification of the variety of post crown applied. The same considerations apply to the crowning of the cuspidati. With the bicuspids, as the great stress is vertical, firm support by the root face is the first consideration and, as the lateral stresses are considerable, auxiliary support may be derived through posts. The lateral stress upon a first bicuspid being greater than upon the second, owing to its greater over-bite, a bifurcated pin furnishes the increased support required.

The same ends are gained in the bicuspids by the use of barrel crowns; the cement underlying them forms a perfect contact with the face of the root, thus affording the full measure of resistance to the vertical stress; the collar embracing the periphery of the root protects it from lateral displacing forces.

With the molars, the greatest stress being vertical, support is demanded from the entire root area underlying the crown. The latter represents primarily a block resting firmly upon a broad base. The lateral stress is guarded against by having one or two posts in the axes of the roots or by the periphery of the crown grasping that of the root-walls.

It is evident that the crown best adapted to meet these stresses is that having a barrel form, grasping firmly the periphery of the root; the retaining cement becomes mechanically part of the tooth, so that these crowns rest uniformly upon the entire area of the root-face.

Pin crowns of the variety placed upon bicuspid roots are occasionally

employed upon molar stumps, but, as a rule, their intrinsic resistance is not as great as that offered by barrel crowns.

Although by their position and form molars receive less lateral stress than bicuspids, the stress transmitted to any one root has greater effect than with the bicuspids, as the line of stress in a molar operates at a greater distance from the line of resistance than it does in a bicuspid, and the leverage represented is correspondingly increased (Fig. 723). As on the natural crowns of molars the lateral stress is less than the vertical, artificial crowns placed upon their roots should be formed so that this is not increased by their presence.

FIG. 723.

Dr. Bonwill has shown the anatomical necessity that the cusps of any tooth be not longer than those of the teeth anterior to it.[1]

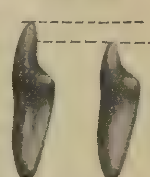
When it is desired to lessen the lateral stress upon molar stumps the end is accomplished by a shortening of the cusps of the crown.

THE FORMS OF THE TEETH.

The great consideration as a governing factor in the placing of artificial crowns is the forms of the teeth. This includes the shapes and sizes of the roots to be crowned as factors determining the type or variety of crown selected.

How does the area of root-section compare with the length of the root? and, again, How do these factors compare with the length and breadth of the occlusal surface of the artificial crown? For example, two roots may have the same length and the same sectional area: one requires a crown half again as long as the other (Fig. 724), or the stress of occlusion may be more severe; obviously, the mechanical stress upon the root is increased in the ratio of the extent of its occlusion or the amount of increased leverage represented in the crown of greater length. Or, again, two roots having the same length, and artificial crowns of the same length and breadth, but the sectional area of the face of one root greater than that of the other, it is evident that the resistance afforded by the root of smaller section will be correspondingly decreased. A long heavy root will bear safely a crown which if set upon a short and narrow root and subjected to an equal stress would result in the loss of the root.

FIG. 724.



PHYSIOLOGICAL RELATIONS.

Under this heading are considered the vital conditions of the tissues of the teeth or roots and of their sources of nutrition and support; if the pulp be alive, what its condition; and whether it is possible or advisable to place an artificial crown without effecting the destruction of that organ. Teeth are occasionally broken in such a manner as to render restoration of form by filling material inadvisable, and yet not uncovering the pulp, the latter being healthy and the dentine normal.

[1] *Proceedings of Columbian Dental Congress.*

It is possible in some of these cases to adjust an artificial crown without destroying or disturbing the pulp: it is evident that modifications of the barrel crown are alone applicable.

Next, what is the texture of the dentine? Highly organized dentine will bear safely a strain which would injure dentine of poorer type. The latter type of tissue is non-resistant to the progress of dental caries, and thus needs protection against contact with or the access of the active causes of caries.

The condition of the enamel rarely is a factor in the plans, except that faulty enamel, through its liability to fracture or crumbling, will sooner or later leave part of a natural crown or a stump for the attention of the prosthetist. It may be that a tooth crown consisting in large part of thin and discolored enamel is removed for æsthetic considerations and replaced by an artificial crown.

The Condition of the Pericementum.—This includes a consideration of the existing vital relations of this tissue, and the possible sources of irritation to it formed by the placing of an artificial crown, or acting after the crown is set.

Pathological Relations.

As teeth which require artificial crowns have been brought to their condition by the action of pathogenic agencies, these if unchecked will ultimately cause the loss of the root itself: they are therefore the most important of the factors requiring attention.

The question of existing pathological conditions and their treatment belongs properly to the province of dental pathology and therapeutics; but the present subject is the common ground upon which the therapist and prosthetist meet: their offices are the two steps of a common operation.

If a tooth contains a vital pulp, and it is designed to retain that organ, the infected dentine, that invaded by the carious process, should be removed with the same care as though it were being prepared for the reception of a filling. Should the pulp be, or have been, the seat of inflammation, it is destroyed and removed. If it is to remain alive, the same care is observed in guarding it against thermal shock as with fillings, so that after placing an artificial crown upon a stump containing a vital pulp there should be no increased response to applications of heat or cold.

When post crowns are indicated the pulp is to be, necessarily, destroyed.

The extent to which the carious process has invaded the dentine is a large factor for consideration, for the greater the loss of the dentine the weaker the root becomes, the less mechanical resistance it affords, so that support may be required to guard the weakened structure against fracture. Again, the more extensive the carious process the greater is the probability of such deep infection of the dentine that an increased length of time is required for sterilizing the infected tissue.

The present condition of the pericementum and its past history are the most important of all considerations. It is possible that a form of crown may be required which will permit of ready removal in case of

recurring pericementitis; however, in a properly treated root such a contingency should be a remote possibility.

The liability or disposition of the pericementum toward inflammation may enforce a lessening of the stress brought to bear upon it through the artificial crown. It is a recognized principle of surgery, and never to be lost sight of in crown- and bridge-work, that a part once inflamed has an increased tendency toward subsequent inflammation.

It is an inflexible rule that before the setting of an artificial crown the root bearing it must have such preliminary treatment that its pulp-canal and substance of its denture are rendered aseptic, and if possible antiseptic, and the pericementum must be brought to a condition of health.

Unless the root be firmly fixed and supported by sound alveolar structures the following operations prove abortive just in the degree that the root is the subject of anatomical or physiological perversion. It must be remembered that the setting of an artificial crown places beyond access the most important means of combating disease of the crowned root, so that the assurance of continued root-health is a necessary preliminary.

Preparation of Roots; Therapeutics.

Under this heading are included, first, the therapeutic measures necessary to secure the continued health of all of the dental tissues and their supports; and next the mechanical preparation necessary to form the root into a resistant base to which a crown may be fitted with exactitude.

If the tooth contain a live pulp which has been the seat of morbid action ranging from congestion to suppuration, it is to be destroyed and thoroughly removed. In single-rooted teeth this destruction may occasionally be effected by the driving process. A piece of orange-wood is made into a long sharp point; the pulp is exposed so that there is direct and perfect access to it: if it be hyperæsthetic, a crystal of cocaine is placed upon it and permitted to remain for five minutes, when the pointed stick is insinuated between the pulp and its walls and driven into the root by a quick blow of a plugging mallet. The stick is then withdrawn, and usually the pulp is found clinging to it. In other teeth, those in which such direct access to the pulp-canal cannot be had, the nozzle of a hypodermic point, attached to a syringe containing a solution of cocaine of from 4 to 10 per cent., is inserted beside the pulp and a drop of the solution forced out; in a few seconds the point of the syringe is thrust quickly into the substance of the pulp, and the injection made.[1] The pulp is then removed by means of broaches. If the necessary apparatus be available, the pulp may be placed under cocaine anæsthesia through the agency of a cataphoretic current. The usual practice is to destroy the pulps by means of a paste of arsenic:

℞. Acid. arsenosi,
Cocain. muriat., $\bar{a}\bar{a}$. gr. j;
Ol. caryophyll., q. s.
M. et ft. paste.

Sig. A minute portion of the paste placed on a small pledget of cotton is laid over the point of exposure.

[1] Dr. Maxfield, *Proc. N. J. State Dent. Soc.*, 1894.

This preparation is sealed in the tooth preferably by zinc phosphate mixed thin, and before it is hardened the access of the fluids of the mouth to its surface is permitted.

The pain following arsenical applications to the pulp is caused in great part by the pressure of the retaining filling material. Zinc phosphate flowed in the cavity causes no pressure, and its wetting, before hardening occurs, renders it easy of removal. In from twenty-four to forty-eight hours the pulp is then removed by means of broaches.

If the pulp be the seat of purulent inflammation or of moist gangrene, it should be removed, so that none of the pathogenic organisms may be forced into the tissues about the apex. The root and the degenerated pulp-tissue are filled with a strong penetrating antiseptic, such as meditrina (a solution of hypochlorites), and this is permitted to exercise its properties before the broach is applied. It is a wise precaution to wash the mouth well with this solution prior to opening any pulp-chamber in which there is putrescible material. When possible, the rubber dam is applied, the cavity dried, and a strong solution of sodium peroxide carried into the canal, gently stirring it with an iridio-platinum broach : as soon as effervescence ceases wash out the canal with sterilized water, and repeat the applications of the peroxide until access is had to the apex of the root.

The dentine of roots which have contained gangrenous pulps is the seat of more or less albuminous decomposition, so that ample time should be taken in sterilizing it, preferably by the sodium peroxide, as this substance is itself decomposed into sodium hydrate and free oxygen : the former saponifies the fatty products of decomposition and dissolves the protoplasmic filaments ; the oxygen drives out the dissolved materials, and effectually destroys any organisms present.

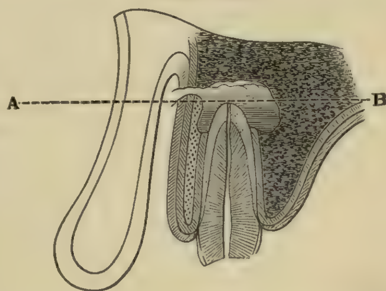
If there be no exudation from the apical tissues into the canal, it is the common practice to dry out the canal by means of alcohol and hot blast, and fill the apical portion of the canal with a gutta-percha cone which has been covered by an antiseptic oil—cajuput, cinnamon, or cassia.

Should the apex of the root be the seat of an abscess, this is to be cured before the apical foramen is sealed. The canal is washed out with the sodium peroxide and cleansed thoroughly : no harm is done if the solution be forced through the root. Succeeding this, a solution of caustic pyrozone is pumped through the canal into the abscess-sac until the pus is driven through the fistula. As a rule, these roots may be filled at once, and the abscess-sac is soon obliterated by the formation of new tissue about the apex of the root. It occasionally happens that the fistula does not close after one injection, so that as a precautionary measure the permanent hermetical sealing of the apex of the canal is deferred until it is seen the fistula heals and the normal color of the gum over the affected tooth is restored.

Cases present at times which give a history of a fistula alternately healing, then opening. Even after repeated injections the fistula will open periodically, and a discharge of pus or serum occur. A condition is present at the apex of the root which demands removal by amputation of the apex. Before the pus formed at the apex of a root makes its escape through a fistulous opening in the gums the destruction of tissues incidental to

or characteristic of abscess proceeds in all directions, so that by the time a fistula is established the end of the root is extending into an irregular cavity, the pericementum destroyed for some distance above the apex, and the uncovered portion of the cementum saturated with noxious material.

FIG. 725.



When the pus above the dotted line (Fig. 725) discharges, the fistula may heal, and remain closed until an increased pus-formation again re-establishes the fistula.

The gum is to be divided above the apex of the root, the pericementum is scraped from a small area, and free entrance is gained to the abscess-cavity by means of sterilized burs. As soon as the bleeding is checked a fissure bur is passed through the opening and the denuded portion of the root cut off and rounded. The sterilization of the canal and its filling have preceded the amputation.

In what are known as blind abscesses, those without a fistulous tract leading from them and discharging externally, it is advisable where possible to make an artificial fistula. The mouth is sterilized and a crystal of cocaine placed on the gum over the apex of the root. The length of the root is measured by a broach in the canal, and this length measured on the gum over the root. A crucial incision is made through the gum, the bone denuded of periosteum over a small area, and a spear-pointed engine drill is quickly passed through the bone and into the abscess-cavity. The case is treated then as a simple abscess. The operation may be made almost painless by injecting a few minims of a 4 per cent. solution of cocaine. The canal is filled after a thorough sterilization, and pending the healing of the abscess-cavity the external opening is kept patulous by means of a couple of strands of floss silk acting as a tent and means of drainage.

Persistent endeavor should be made to enter freely and cleanse out perfectly to the apex all the fragments of pulp-tissue in the roots of teeth, even in the most minute canals. The introduction of the use of sulphuric acid, in connection with broaches, for gaining entrance to, enlarging, and cleansing canals, by Dr. J. R. Callahan,[1] has added to the operations of dentistry a most valuable expedient, and furnishes a means for the removal of a common cause of apical pericementitis, imperfect removal of pulp-fragments. A drop of a 50 per cent. solution of sulphuric acid is placed over the mouth of a fine canal, and pumped into it by means of a fine Donaldson broach.

Much patience will be required to effect the desired end in some teeth, but so long as there is an imperfectly cleansed canal there is the ever-present fear of the possibility of abscess, and if the crown be properly set, it is most difficult to cure the diseased condition.

Roots or teeth which have a portion of their surface overgrown by a hypertrophied gum-tissue must have the latter removed, so that the

[1] *Dental Cosmos*, vol. xxxvi. p. 329.

field of operation may be open. If it be a pendulous mass, the gum is excised sufficiently to free the root outline. If the margins of the root be covered by the gum, it is to be pressed back until the field of operation is free. The canal and the pockets beneath the gum margins are washed out with meditrina and the canal and face of the root dried. A block of temporary stopping is made and formed into a truncated cone, the small end of which is pressed against the face of the root, and the mass is flattened so that it presses the gum away from the root on all sides. "Should there not be sufficient concavity in the root to hold the stopping, a large-headed carpet tack may be pressed into the canal and the gutta-percha wedge built around the post."[1]

Mechanical Preparation of the Root.

The manipulations included in the mechanical preparation of teeth or roots for the reception of artificial crowns are of two varieties: first, the reduction of the existing volume to the necessary form and dimensions; second, those cases in which it is necessary to restore in part the form of the root lost by decay, so that it will serve as a base for a crown.

Fig. 726.

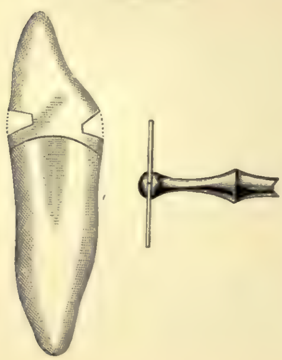
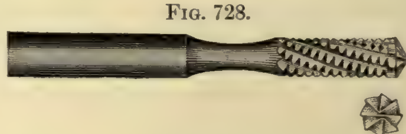


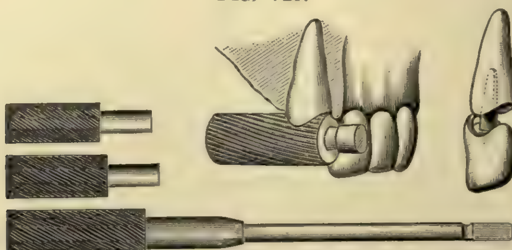
Fig. 727.

Fig. 728.



Crowns supported by posts should be so adapted to the roots upon which they are placed that their peripheral junction is as nearly perfect

Fig. 729.



Herbst's rotary files.

as possible; there should be nothing between their surfaces but an attenuated layer of the retaining medium. At no point should the

[1] Wm. H. Trueman.

surfaces overlap; an instrument passed around the line of union should discover no projection of the crown beyond the root.

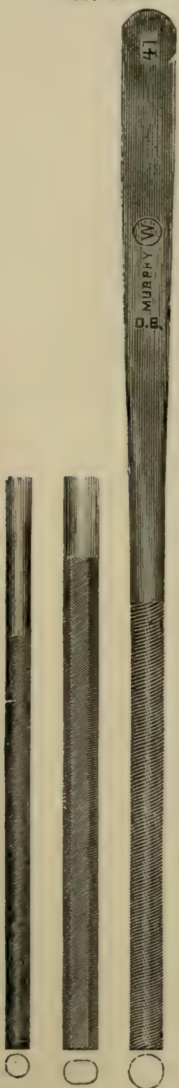
Roots should be so prepared that they furnish adequate mechanical support to their artificial crowns. As they represent also restoration of form, their bases should be so shaped as to permit the accurate adaptation of anatomically correct substitutes.

The first class of root- or tooth-shaping operations are found in those cases where it is necessary to reduce an entire crown or a considerable portion of one to desired dimensions.

When decrowning is necessary to fit teeth containing vital pulps for service as the bases of abutment crowns of dental bridges, they may be removed after the following manner: The edge of a diamond or sharp corundum disk is applied to the outer and inner walls of the tooth until it is deeply grooved (Fig. 726); the edges of a pair of excising forceps are then placed in the grooves, and by a sudden pressure the crown is broken off, leaving the pulp protruding. This organ is then destroyed by the driving-out process or extirpated after cocaine injection. This method, if practised upon teeth containing dead pulps, is occasionally followed by obstinate pericemental disturbance.

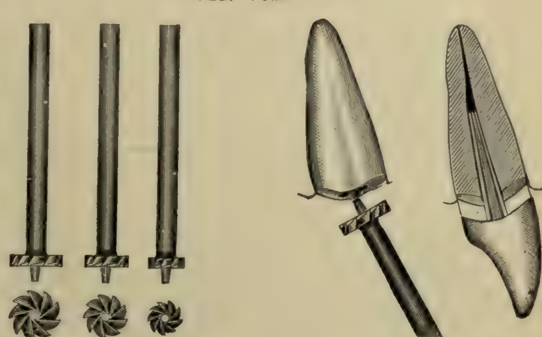
The crowns of pulpless teeth may be readily removed by making with a spear-pointed drill a series of perforations from the outer to the palatal surface of the tooth; these should all be in one line, about one-sixteenth of an inch above the gum margin (Fig. 727). A dentate fissure bur (Fig. 728) is passed through the middle opening, and by cutting laterally the crown is soon removed. Irregular fragments of crowns may be

Fig. 730.



Pivoting.

Fig. 731.



Facers. Root-facers.

chipped away piecemeal by means of a small pair of excising forceps until they are almost on a line with the gum margin. The shaping of the root face may be accomplished by means of oval files made for that purpose (Fig. 730). Stump corundums are effective instruments

for the same purpose, but better than either are the rotary files of Herbst (Fig. 729), which shape the root face as it should be, its edge parallel with the gum margin.

The trimming is continued until the root face is at uniform depth of about one-twentieth of an inch beneath the gum line. At its labial aspect the cutting should be slightly deeper, so that the line of junction of crown and root may be effectually concealed.

A safe and rapid method of reducing the faces of roots or of cutting down broken teeth is by means of Ottolengui's root-facers. Their action and application are illustrated in the cut (Fig. 731).

Reducing Teeth for Barrel Crowns.

It is essential that the edges of all barrel or collar crowns shall form a perfect joint with the periphery of the root. This portion of the root should have a greater sectional area than any portion of the tooth over which the barrel is passed in adjusting it. The walls of the root and tooth should therefore be at least parallel above the crown edge line, and it is better if they be given a slight slope, so that in placing the barrel it is being thrust over the frustum of a rounded pyramid (Fig. 732). It will be noted in the appended figures that the periphery of the roots of the teeth are usually larger at the gum margin than at a point one-sixteenth of an inch beneath this margin; moreover, the form changes, so that a tooth or root must be so formed that the portion of the crown or root extending beyond the gum has a less circumference than the portion one-sixteenth of an inch beyond the given margin.

The evils attending and following the placing of this class of crowns are due in great part to inaccurate adaptation of the edge of the collar to the periphery of the root. It is a task of some little difficulty to properly shape a root for the reception of a collar crown, and no easy operation to accurately fit a metallic band to the prepared root.

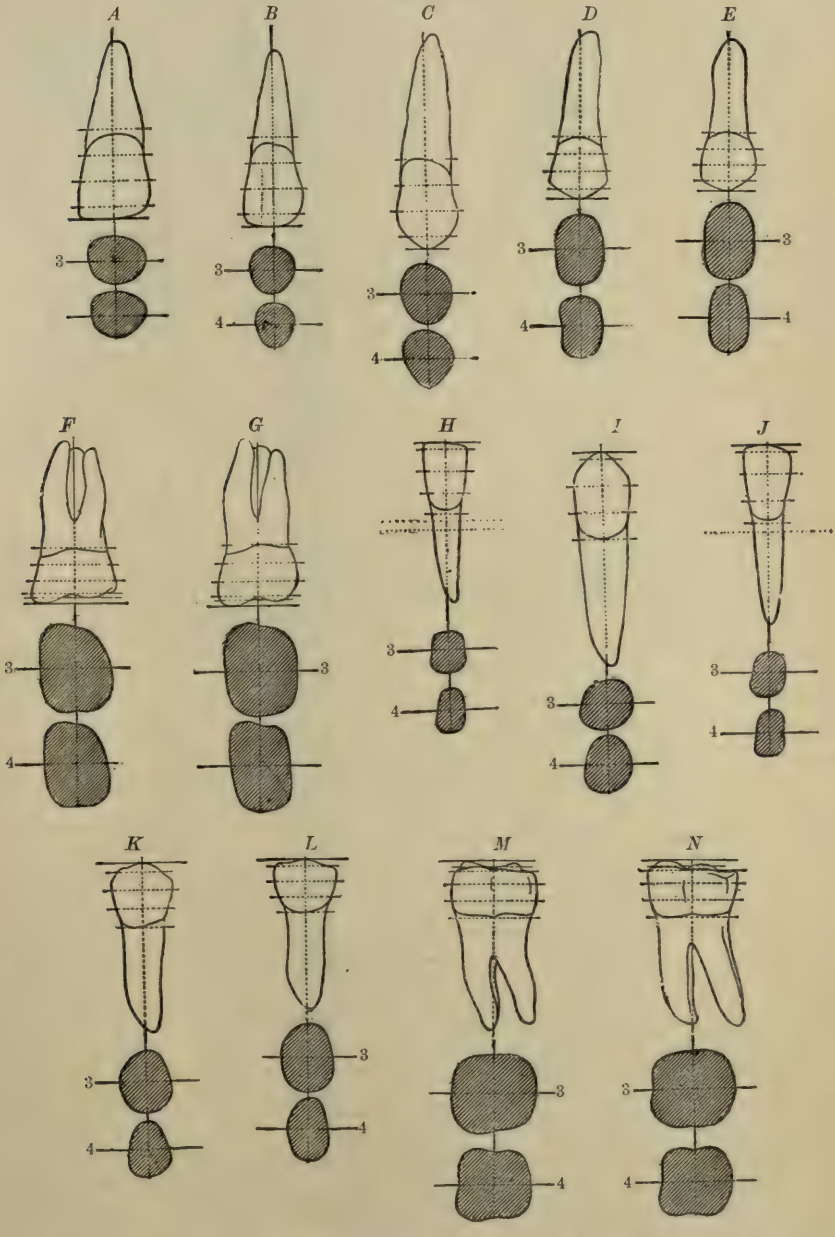
It is a common observation that very many, perhaps a great majority, of these crowns are imperfectly fitted or the root improperly prepared. An instrument passed around their borders discovers the existence of an irregular shoulder produced by the lack of adaptation of the barrel edge (Fig. 733, *a*). Such spaces form pockets in which food deposits and secretions find lodgement, so that the irritation produced by the projecting collar edge is increased by contact with the products of fermentative decomposition of the deposits, and localized gingivitis and pericementitis are liable to occur.

The sectional area at the gum line is greater than beneath it, so that a barrel fitted to a root cut off at the gum margin would necessarily leave projecting edges if forced above that line. The line of crown and root adaptation should be as shown in Fig. 734.

In cutting down large tooth remnants, such as molars, to the slightly tapering form required, a large revolving disk of corundum or a diamond disk (see Fig. 726) is held against the four walls, and its edge carried slightly beneath the gum margin until the tooth represents a truncated pyramid: the disk is carried over all accessible portions of the walls. The corners of the teeth or some of them are usually inaccessible to the disk, so that they are to be shaped by means of smaller implements,

small corundum points, tapering burs. An effective instrument for this purpose is found in Dr. C. S. Case's enamel-cleaver (Fig. 735).

FIG. 732.



A crown or tooth remnant entirely freed of its enamel has the correct form for the proper adjustment of barrels or collars, so that

in broken-down teeth their walls may be shaped by the removal of the enamel through the aid of these instruments.

The instrument of Dr. W. S. How (Fig. 736) and those of Dr. R. W. Starr (Fig. 737) are used to give the proper form to roots for the reception of collars.

FIG. 733.

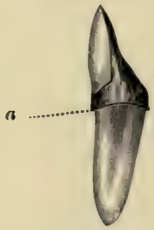


FIG. 734.

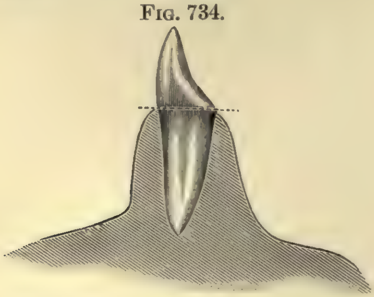


FIG. 735.

FIG. 736.

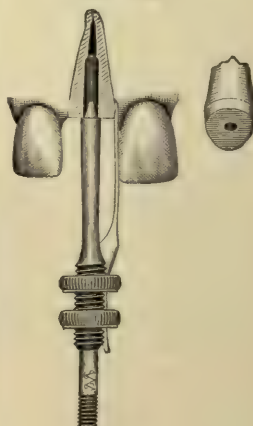


FIG. 737.

Crowns which depend for retention upon a barrel are to have as much of the tooth stump left as possible compatible with perfect adaptation of the crown, and, if for anterior teeth, with the non-exposure of the gold.

RESTORING ROOT FORMS.

It is necessary that the root of a tooth should possess sufficient strength and such form as to furnish a firm support to the artificial crown.

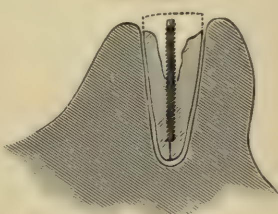
Occasionally cases present in which there has been such extensive loss of tooth-substance that hypertrophied gum is found overhanging the edges of a root which has been extensively invaded by the progress of caries. In such cases the root form is to be restored sufficiently to furnish a good base. After the free application of powerful but unirritating antiseptics to the recesses of the gum and the cavity of the root, masses of temporary stopping are employed as described to free the interior of the root and its face from the overlying gum. The root is thoroughly sterilized, its pericementum brought to a condition of assured health, and the apex of the canal sealed.

It is now required to restore the root form by means of some rigid and insoluble material. All things considered, a good amalgam is the material best adapted for this purpose. If the root is that of a bicuspid or a molar, one on which a collar crown is to be placed, the filling mass is built down so that the collar encloses it, finding its support in the filling, and, if possible, through some grasp upon the root also.

The first step is fitting a matrix to the root in which the amalgam is to be packed. A small cylinder of moldine is packed over the root face, its external portion being left as a bulbous protrusion. While the moldine is in position a small impression-tray filled with the same material is used to secure and withdraw the mass covering the root face. Into this impression a fusible-metal cast is run, on which is adjusted a tube of German silver or copper, fitting the root accurately and being deep enough to grasp the periphery of the root firmly and to extend one-eighth of an inch or more above the edge of the gum. This tube is placed in position—the rubber dam adjusted over it and the adjoining teeth.

The root is next dried well and filled with a strong antiseptic. The canal is cleaned and tapped for the reception of a metal screw; after placing a small piece of soft phosphate of zinc on its extremity it is screwed into place (Fig. 738).

FIG. 738.

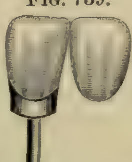


The root is given an undercut and grooved to aid in retaining the amalgam. Amalgam is packed about the pin, over the root face, until the tube is filled to dotted lines (Fig. 738); this is done by using a ball of bibulous paper, which is held in a pair of pliers and applied to press out all surplus mercury, which is then removed, and the filling completed with amalgam from which the surplus mercury has been wrung by means of heavy pliers. When the tube is full, use sponge gold to rub into the amalgam and absorb any free mercury. The filling should be hard before removing the rubber dam. An alloy containing at least 55 per cent. of silver and 5 per cent. of copper should be used.

After twenty-four hours the tube should be split by cutting through it with a hatchet excavator, the ends bent back and removed.

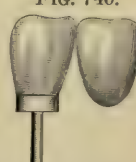
At the external (labial or buccal) edge the amalgam should be ground down to a level with the border of the gum. If desired the tube may be made of thin platinum, which is to remain, covering the amalgam mass. For anterior teeth, when a pin support is required in addition to the collar, special provision must be made for it. After placing the cylinder over the root and adjusting the rubber dam, a platinum tube is made of thin plate and of a diameter to receive a No. 17 wire. This is to be anchored for the reception of a post of that size. The wire, one-eighth of an inch longer than the tube, is touched with vaseline and inserted in the tube, a small pellet of zinc phosphate is placed in the canal, and the tube and wire pushed into position. This tube and walls

FIG. 739.



Correct cervical outline.

FIG. 740.



Faulty outline.

of the cylinder encircling the root must be parallel, or the finished crown cannot be placed properly. Undercuts are made and amalgam packed as described before. When the amalgam has set the wire may be withdrawn from the inner tube, having been greased lightly; the zinc phosphate does not retain the distal extremity. If the outer tube is of platinum, it may remain if the operator desire.

In shaping the external cervical margins or edges of roots care must be exercised to give them such an outline that the artificial crown has a cervical edge of the same outline as that of the adjoining teeth. Disregard of this precaution produces unsightly results. Particular care must be taken in shaping the external border of collar crowns, as upon this detail depends not a little of the artistic success of the piece (Figs. 739 and 740).

Requisites of a Crown.

Artificial crowns should, as nearly as possible, restore the appearance and function of the natural teeth. Moreover, by their presence they should afford no more opportunity for the action of disease-producing agencies than when a natural crown is upon a pulpless root. This rule is impossible of exact fulfilment, but it is possible that by a correct artificial crown, properly placed upon a healthy root, the possibilities of disease processes arising may be reduced to a minimum, and by an improperly made or placed crown the probabilities of subsequent disease are increased.

All crowns must rest firmly upon the face of the root upon which they are placed. The contact must be at all points of the edge of a crown with the tooth surface. If of porcelain, it must correspond in shape, size, shade, and position with its fellow, and must subserve the purposes of a crown in mastication.

There should be at no part any projection which can form part of a pocket, nor any point which can act as an irritant to vital tissue. The line of junction between tooth and crown should be clean and clear, so that neither the surface of the root projects beyond the edge of the crown nor the edge of the crown beyond that of the root.

If a barrel or collar crown, the upper edge of the collar or barrel must be in close contact with the root surface. It should extend far enough beneath the margin of the gum to grasp the root firmly, but should not extend to the alveolar border. A limited portion of pericementum is destroyed in trimming a root, and the collar should not extend beyond this point: as the collar represents or replaces the upper border of enamel, it should not extend much beyond the depth of the enamel line unless the gum should have receded from about the tooth.

Porcelain crowns should have the porcelain protected against fracture, either by the inherent strength of all porcelain crowns themselves, their bulk supplying the strength required, or, if a porcelain facing, the facing should be protected by a metallic backing against the force or shocks of mastication.

For posterior teeth the details as to correspondence of size and contour are equally important, and in addition their articulating surfaces should have such an arrangement of cusps and sulci that the normal masticating surface is restored.

TYPE SELECTED.

As a general rule, no root anterior to the second bicuspids should be crowned with an all-gold crown. None of the incisors or cuspids should show any but a porcelain surface. Healthy roots which have not been invaded by caries, if of good size and structure, as a rule, may be fitly crowned with some form of the pin crown.

Logan crowns are adapted when the root is of good structure and when form and color corresponding exactly to the adjoining tooth can be had, and when the bite is not too close to cause weakening of the porcelain by the necessary grinding, and where the correct cervical surface outline can be had.

The pin and plate crown is adapted for use on sound roots. This variety produces a greater mechanical strain upon a root than does the Logan, as the force received by it is directed first upon the anterior wall of the pulp-canal; second, upon the outer surface of the root. With the Logan crown the force received is transmitted primarily to the outer surface of the root, and stress is exerted secondarily upon the walls of the pulp-canals. The Logan crown can therefore be used upon more frail roots than the pin and plate variety, as the stress tending to fracture a root longitudinally is greater with the latter.

PARTIAL CROWNS.

Occasionally cases are seen where the loss of tooth-substance is not sufficient to demand the sacrifice of an entire crown to be replaced by one of the artificial crowns described, and yet is so extensive or in such situations that restoration by means of filling materials is impracticable: it is at times advisable to apply one of the devices known as partial crowns.

The first variety of such cases are those in which one of the anterior teeth has been fractured transversely at about the middle, without exposing or destroying the vitality of the pulp.

Usually these cases have the contour restored by means of heavy rolled foil at the hands of the operator. As the appearance of a mass of gold in so conspicuous a place may be objected to by the patient, the operator is compelled to resort to the use of porcelain to effect the restoration.

The difficulties of this substitution are—securing sufficient support for the porcelain tip; accurately matching the color of the natural tooth; disguising the line of juncture of tip and tooth; and lack of strength in a porcelain piece of such size.

FIG. 741.

The surface of the broken tooth is smoothed and squared, and dressed to as great a depth as possible without exposing the pulp. Upon this prepared surface a piece of platinum plate No. 35 is burnished to close adaptation (Fig. 741).

At three points holes are drilled, the middle one not on a straight line with the others, as deep as may be without encroachment upon the pulp: these cavities are to be made while the platinum plate is on the tooth; in each of the openings a screw is placed, fitting the cavities easily. Adhesive wax flowed over

the projecting ends of the screws attaches screws and plate, which are removed in one piece, invested, and the screws united to the plate by means of 24-carat solder.

The piece is transferred to the root, the exposed ends of the screw dressed to within one thirty-second of an inch of the plate, and the plate burnished to perfect adaptation with the tooth surface. At the labial aspect the platinum is dressed to the tooth outline, and made so thin that its edge is almost imperceptible.

A plaster impression of the parts is taken in which the small plate is withdrawn. A model of sand and plaster is poured with the utmost care, and when very hard the impression is picked away.

A cross-pin tooth having the pins very close to the cutting edge is selected. Its color should match as nearly as may be that of the tooth upon which it is to rest. It is better to have the tooth a trifle more yellow than its fellow, as the presence of a platinum backing gives a bluish tinge; if the tip is blue, a 24-carat gold backing produces a yellowish tint.

The porcelain is fitted by means of fine corundum wheels until the line of union is as nearly perfect as can be made. It is backed with platinum No. 28 or 24-carat gold No. 27, attached to the plate with adhesive wax, and then sand-and-plaster investment is used to cover the porcelain and retain it in position.

At the palatal aspect the porcelain is dressed out to expose the heads of the screws. When the investment has set the adhesive wax is removed, and small pieces of thin platinum plate are used to fill the little space between the base of the porcelain and the plate. Solder with 24-carat gold if the plate and backing are of platinum, or with 22-carat solder if of gold.

Finish and set with zinc phosphate, permitting the cement to set half an hour before removing the rubber dam.

If the pulp has been exposed, it is destroyed and anchorage secured in the canal by means of a long pin.

Incisive edges may be made of gold for pulpless teeth after the following method: The labial edge of the tooth is filed square. A piece of thin platinum, No. 36, is pressed into accurate apposition with the broken edges and surface of the tooth, and burnished over the edges for about one-sixteenth of an inch. The plate is perforated over the pulp-canal, and a platinum wire of No. 18 gauge is thrust through the perforation: the platinum film grasping it tightly on all sides, it is withdrawn, bringing the plate with it. The pieces are united by means of pure gold as solder, and returned to the tooth and burnished into perfect apposition. A bite is taken, and next an impression, in which the post and plate are withdrawn. A model and articulating model are made; the amount of restoration required is noted. A stick is carved to represent the cutting edge, and is driven into an asbestos mat deeper than the necessary height of the tip. Pure gold is melted in this depression, and while molten its upper surface is flattened by quickly pressing against it a smooth piece of charcoal. The protruding end of the post is filed down to within one thirty-second of an inch of the plate. The gold ingot is filed to a close joint with the labial edge of the plate: its inner surface may be short of contact to perfectly admit solder.

The cutting edge is filed to an accurate occlusion, but left a trifle

long to allow for loss in finishing. The surface of the platinum and the base of the tip are covered by borax. If the model has been made of investing material, enough of it is placed over the tip to hold it in position. If of plaster, an opening is made in the model to gain access to the base of the pins. The tip is cemented to the plate by means of wax flux; pressure upon the end of the post pushes the fixture from the model. It is invested and soldered from its palatal surface with 22-carat solder. Its surfaces are dressed down to the proper contour, the overlap of the platinum at the base giving the base outline, to which the piece is to be filed. It is smooth, polished, and set with zinc phosphate.

A better method is constructing the tip entirely of porcelain; this may be accomplished by selecting the tip of a porcelain tooth, adapting it to a plate as described; the attachment of the two is made by adding fusible porcelain and baking in a furnace. (See also methods in Chapter VI.)

Shells of gold having the appearance externally of large fillings are occasionally employed in restoring the contour of teeth. The method is particularly applicable to cases requiring a large phosphate filling. The gold serves as an outer shell which by its smooth surface and protection of the phosphate from the action of the fluids of the mouth preserves the cement from disintegration for a long period. A satisfactory method of forming these pieces is as follows: The tooth is excavated as for a phosphate filling; the enamel edges are made smooth, clear, and distinct, then bevelled. Should the cavity occupy only the masticating surface of the tooth, a piece of softened modelling compound is placed in the cavity and the patient directed to close the bite. A piece of heavy pattern foil is then laid over the compound and bitten upon. When the foil is removed the compound is short of occlusion about the thickness of No. 30 plate. The cavity edges are cut clear of the compound, showing their outlines distinctly. An impression is taken in moldine and a die made. A piece of pure gold of No. 30 is annealed, swaged on this die, and its edges filed to fit the cavity outlines perfectly.

Small openings are drilled through the cap to receive the ends of wire loops. Pieces of No. 22 wire about one-quarter of an inch long are bent into U form; four of them are required to hold the cap perfectly. The loops have their ends thrust through the openings, a minute piece of No. 22-carat solder placed beside each exposed end, the cap laid on a block of charcoal, and the solder fused by a fine blowpipe flame. It is safer to cut depressions in the die corresponding to the positions of the loops, then dress down the ends and reswage (Fig. 742).

FIG. 742.

Should the cavities include the approximal walls, the tooth form is restored by means of zinc phosphate; the cavity edges, which have been dressed, are scraped free from the cement. Particular care is required when the gold extends over the masticating surface that the phosphate be cut down to allow for the lamina of gold. An impression is taken and a fusible metal die made. When the approximal space is minute, it will be necessary to pass a saw-blade between the teeth on the die to represent the space. A piece of 24-carat plate No. 30 is swaged and burnished to fit the outlines on the die, and openings made for two loops—one on the masticating, the other on the approximal wall.

The piece is transferred to the natural tooth and its edges burnished into accurate apposition with all the bevelled enamel edges. Removed from the tooth, the wire loops are placed in position and soldered. It is advisable to flow solder in the angle to stiffen the piece. (See Fig. 743.) The rubber dam is adjusted and the greater portion of the cement is cut out. A mix of plastic phosphate is made; small portions are packed in the loops, and next the cavity itself is filled, when the facing is pressed into place. The piece should now remain undisturbed for at least fifteen minutes.

Fig. 743.

In cavities involving both approximal walls and the masticating surface the piece is shaped and the retaining bar placed as in Fig. 744. Another application of the device is seen in Fig. 745.

Fig. 744.

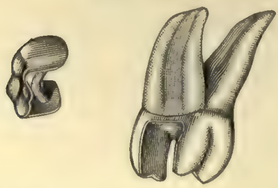


Fig. 745.

Gold blocks, to be placed in lieu of gold fillings made of foil, are constructed after the following method: The cavity, usually in an incisor, is to have its edges trimmed and squared. A piece of annealed platinum No. 50 is pressed and burnished into the cavity and over its margins. In the platinum form adhesive wax is placed and carved to the proper contour. It is chilled, withdrawn from the cavity, and invested in a mixture of pumice and plaster. The wax is burned out, and in the matrix pure gold is melted under a fine blowpipe flame. The piece is trimmed and smoothed to correct contour. It is retained in the tooth by means of zinc phosphate.

The Post and Plate Crowns.

These are crowns which have posts fitting the enlarged pulp-canal for support. The proper size and shape of this post are about those used in the familiar Logan crown.

A root which has lost no substance, or no more of the periphery of its pulp-canal than will receive a post of this size, is usually a fit root for the application of a post crown. Should there be a loss of substance in excess of this amount, a supporting band is advisable.

The size of the post may also be had in a flattened wire of 14 B. & S. gauge and somewhat tapered toward its extremity. The flattening increases the resistance in the long diameter, which occupies the antero-posterior line of the pulp-chamber, the line of greatest strain. Round and square posts are needlessly strong for one diameter, insufficiently so in the other. When the pin is double, as in bicuspids and molars, round or square pins may be employed.

The old type of post, the wood pivot, has been so entirely superseded that it scarcely needs description. These crowns were anchored by

means of round hickory sticks, which were compressed immediately before using. A suitable crown selected was ground to the root face, the compressed wood set in its base, and then the post was thrust into the enlarged pulp-canal. Roots have been split, frequently, through the swelling of the compressed wood.

The form of made-up post crowns most commonly employed is selected as the typical form: it is the pin and plate crown. A detailed description of this will serve to illustrate many of the principles governing the making of all crowns.

The method of making is as follows: An incisor or cuspid root which is in a perfectly healthy state is thoroughly sterilized, and the apical foramen hermetically sealed by some unchangeable material which has been coated or saturated with a strong antiseptic; usually a gutta-percha point is used for this purpose, one which has been soaked in one of the antiseptic oils.

The pulp-canal is enlarged for about two-thirds its length, in such shape as to receive a flattened pin of iridio-platinum wire of No. 14 B. & S. gauge, which is to fit the enlarged canal easily enough to permit ready removal.

FIG. 746.

FIG. 747.

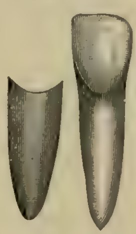


FIG. 748.

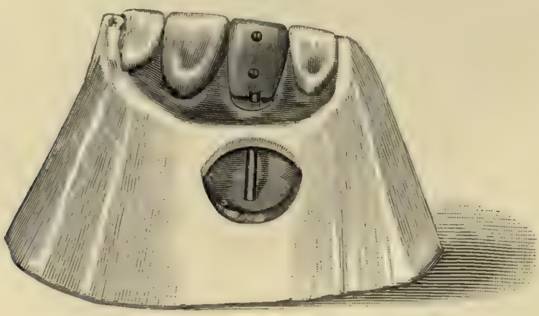
FIG. 749.

The face of the root is shaped to follow the outline of the gum margin, and to have its surface about a line below this margin (Fig. 747). At its anterior aspect the cutting should be a trifle deeper than at the other parts, to ensure perfect hiding of the joint. The operator may now, if he prefers, take an impression of the face of the root, and fit the root-plate on a model prepared from it. An effective method is as follows: After shaping the post-canal and face of the root and fitting the post, Mellotte's moldine is placed around the pin, covered by damp tissue-paper, and inserted in the root; an impression in moldine is then taken; after removing from the mouth the post is withdrawn and placed in position in the impression, and a die of fusible metal made. Should the paper and moldine be scraped from the post in removing it from the canal, it is to be again covered by moldine enclosed in the paper before placing it in the impression.

The thin layer of moldine covering the post permits its withdrawal from the die. A small piece of soft platinum plate No. 31 or 24-carat gold plate No. 30 is well annealed and placed upon the root face represented on the die, and pressed into rough adaptation (Fig. 746): a piece of erasing rubber answers well as an elastic counter-die for this purpose. A buckshot or a small piece of soft lead is placed over the root face on the die, and struck with a hammer until it is fit to serve as a counter-die.

The small plate, again annealed, is placed between die and counter and swaged with a light hammer. A hole is made in the plate to uncover the root opening, small enough to require force in pushing the post

FIG. 750.



through it, so that the post, when in position, is closely embraced on all sides. The post is then withdrawn, the plate coming with it; borax is applied at the line of junction, and if the plate is platinum it is soldered with a small piece of 24-carat gold, or, if the plate be of gold, with a

FIG. 751.

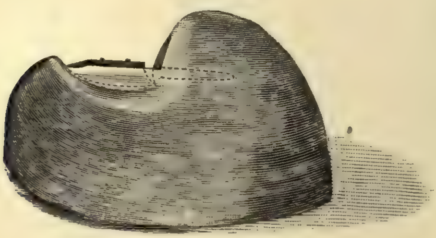


FIG. 752.

minute piece of 22-carat solder. The plate is then trimmed to follow the root outline; at its labial aspect it is filed to a thin edge (Fig. 748).

The post and plate are placed in position on the natural root, and with an orange-wood stick and a light mallet tapped at all points until the adaptation is perfect.

A bite of wax which includes the adjoining teeth is now taken, removed, and chilled.

Next a plaster impression is secured, in which are withdrawn the post and plate; if not withdrawn in the impression, a depression is seen, in which the top of the pin is inserted.

A shade tooth is selected at this time. The impression is double varnished with thin shellac and thin sandarac, allowing each varnish to dry well. Pins are placed in the impressions of the teeth adjoining the root to be crowned, and poured carefully with rather thin plaster, to be sure the impressions of the tips of the teeth are perfectly filled. Let this set well before separating the model from the impression; place the wax-bite in position on the model, and make an articulation on a crown articulator.

Varnish with thin shellac the teeth of the models.

Saw off the protruding end of the post to within one-sixteenth of an inch of the plate; the anterior edge of the post may be bevelled even with the plate; removing more than this weakens the post attachment to the plate.

A plain plate, straight pin tooth, having a shape, size, and color corresponding with the adjoining tooth, is then selected. Straight pin teeth are stronger than than those with cross pins; but the lower pin must be in such situation that it will not be ground out in the fitting. Grind the tooth with fine grit corundum wheels until the cervical portion fits perfectly the outer edge of the plate and has the same contour: the cutting edge should be precisely on a line with its fellow and restore the general curve of the incisors, repairing the break of the arch line.

FIG. 753.

Bevel the palatal aspect from about one-eighth of an inch beneath to the cutting edge, and bevel the porcelain beneath the lower pin to expose the head of the post (Fig. 753). Make a small plaster wall to hold the tooth while fitting the backing stay.

Should the tooth be a little too blue in color, use 24-carat plate for backing; if a trifle yellow, use platinum plate.

A closer adaptation of the backing may be made by using well-annealed plate of No. 35 gauge, and placing over this plate of No. 28 or 27 gauge. The thin plate should be well burnished over the entire palatal aspect, and turned under at the cervical portion. The stay should extend clear to the cutting edge of the tooth to ensure protection to the porcelain during mastication (Fig. 749). With a wedge-shaped chisel split the pins and turn back the sections, so that the backing is firmly held. Boil the tooth and plate in pickling fluid; place in position on the model; unite plate and tooth with adhesive wax.

Remove from the model and invest in sand and plaster. The removal from the model without deranging the parts may be readily effected as follows: At the palatal aspect cut away the plaster of the model until the post is exposed (Fig. 750); the fixture may then be pushed out by pressure on the end of the post. The piece is then invested in sand and plaster (Fig. 751).

When the investing material has set, remove the adhesive wax; fill the V-shaped space between tooth and plate with thin pieces of 24-carat plate; apply borax; cover with small squares of 20-carat solder; dry out; then heat slowly from the investment side; when the tooth shows red by heat transmitted through the investment, turn the fine blowpipe flame on the plate and backing, and the soldering will be perfect. Cool gradually; pickle and finish with all the care a jeweller exercises in the finish of his work. The outlines of the crown should then be in exact correspondence with the outlines of the root (Fig. 752).

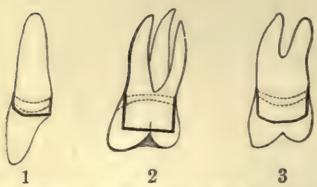
Collar Crowns.

The second class of crowns are those in which retention is by means of encircling collars or bands. As the band is the distinctive feature of this class, it will be first described.

The first requisite of this band is that it shall fit absolutely, not approximately. Faults in this direction are the most common and those to be most guarded against. The second requisite is that these bands shall not be irritating to the vital parts, and yet shall offer a perfect protection against the ingress of pathogenic organisms or their products to the parts we design to protect. This implies that the band shall not impinge on the pericementum, nor must it have any roughened edge or surface to irritate the overlying gum. It should extend to such depth beneath the gum margin that the gingival margin shall form a barrier, not the wall of a pocket. The band should grasp, but not irritate; a trifle over one-sixteenth of an inch in depth will be sufficient in the majority of cases.

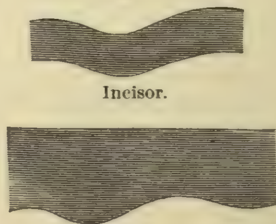
The surface having the greatest sectional area should be at the edge of the collar or barrel. This requires that the root be so trimmed that

FIG. 754.



Outer lines represent original contour; inner lines, the form to receive barrels or ferrules.

FIG. 755.



Patterns for collars.

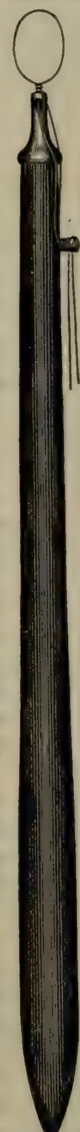
its walls are at least parallel (Fig. 754). It will save the patient discomfort and the operator material if after shaping the root an accurate impression of the parts be taken. On a model made from this impression a pattern, following the gum line, should be shaped. From this pattern a piece of plate is cut, 22-carat, No. 29 or 30 (Fig. 755). This is annealed and bent to fit the root or tooth on the model.

Annealed and transferred to the mouth, the band is pressed into close adaptation, and a scratch made indicating the amount of overlapping of the edge. Remove this and cut a trifle—say one-twentieth of an inch—beyond the scratch to allow for stretching. File the edges square, apply borax, and hold them in firm contact with one another, either by use of binding wire or by overlapping the edges, and then bringing back into direct contact, so that they will be held together by the elasticity of the metal itself. Place on the inside of the collar a small piece of 20-carat solder, and fuse by holding in a small Bunsen or large alcohol flame.

Another method of fitting the collars is as follows: The perimeter of the root is taken by means of annealed brass wire of No. 33 gauge. The ends of the wire are passed through the end openings of a dentimeter, one end being caught fast upon the side pin of the instrument, and by drawing upon the loose end the nose of the dentimeter is drawn to within an eighth of an inch of the outer face of the root, when the instrument is turned, twisting the wire and drawing it closely about the neck of the teeth. The opposite edge of the wire loop is held down by means of an instrument to prevent it slipping off the root.

The loop is removed (Fig. 756) and divided at a point opposite the twist and straightened. The line of greatest distance between the gum line of the root to be crowned and the antagonizing tooth is measured, and a rectangle of plate of that width and the length of the straightened wire is cut. Should the area of the root face be noticeably less than that to be filled by the articulating face of the crown, the plate is to be cut in the form of a trapezoid, its short parallel side somewhat shorter than the length of the wire. The ends to be joined are filed perfectly square and covered by borax and soldered.

Fig. 756.



Kirk's dentimeter.

The cylinder may be then placed upon an appropriate mandrel, and pressed up on it until it fits tightly, giving an approximate form to the cylinder.

If the operator prefer he may employ a seamless gold collar procured from the manufacturer, and form this upon a mandrel (Fig. 757). Making a soldered cylinder for each case is, however, a more precise method; moreover, it permits of making the circumference of one edge of the collar greater than that of the other when this difference in the sizes is demanded.

The exact neck forms may be given in the following manner: Lay the wire loop as it comes from the tooth upon a smooth flat lead surface, and place over it an old tool-handle sawn square and given a smooth surface. Strike the wood a hard blow, driving the wire into the lead and wood, leaving both lead and wood marked by the outline form of the wire (Fig. 758). The wire is straightened, the gold measured, and the cylinder made as described. It is then bent to fit the indentation made by the wire in the wood, and next further adapted to the groove in the lead. It is then transferred to the root in the mouth, the outline of the gum margin marked on its surface, and the collar trimmed to this line.

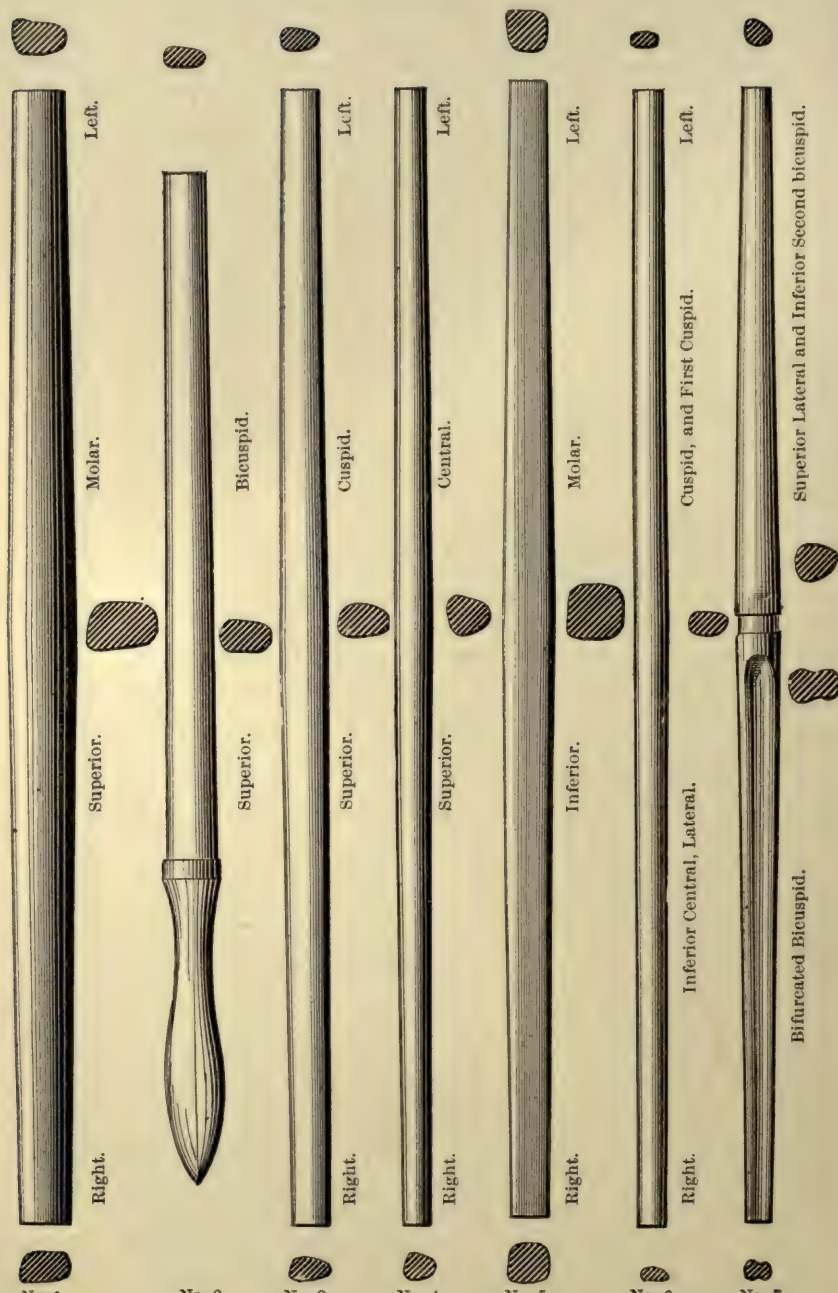
It is set upon the root until one portion of it touches the gum, when the outline to which the edge of the collar must be cut is noted, so that it shall be at a uniform depth below the gum line. The collar is cut to this line, transferred to the root or tooth, and pushed into position.

Subsequent manipulations depend upon the class of tooth to be replaced, for there are many modifications of the subsequent operations depending upon whether the tooth has or has not a vital pulp, and whether the root is that of an incisor, cuspid, bicuspid, or molar.

As the molar is the commonest of barrel crowns, it will be described first. There are many time-saving methods recommended and applied in the making of these crowns, but in most of them time-saving is at the expense of æsthetic results.

The following is a method devised about ten years ago by the writer, and followed ever since to the exclusion of all others: The band is first made as described above, and cut down to within an eighth of an inch or

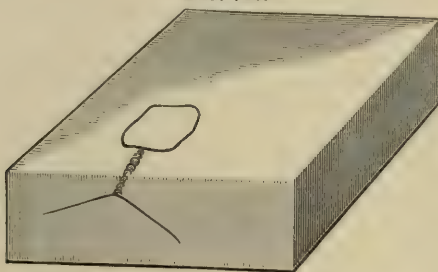
FIG. 757.



Mandrels for shaping seamless tooth-root collars.

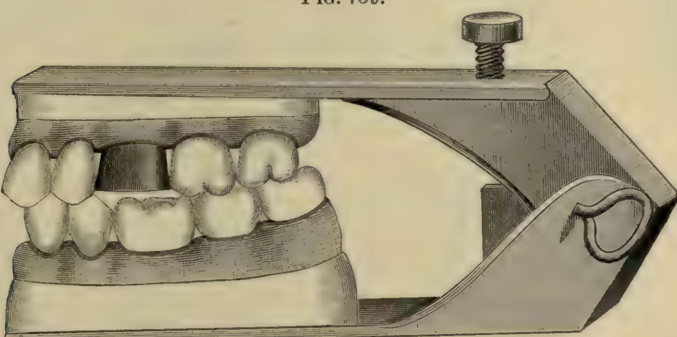
so short of occlusion, leaving a square edge. A wax-bite is taken on this, including two or three adjoining teeth and removed. A plaster impression is then taken, in which the barrel is imbedded and withdrawn. A

Fig. 758.



model and articulating model are made and mounted, preferably on a Bonwill articulator, but usually upon the crown articulator, as in Fig. 759. While the barrel is upon the plaster model the walls are to receive their correct contour. The catalogues of the manufacturers exhibit an ever-

Fig. 759.



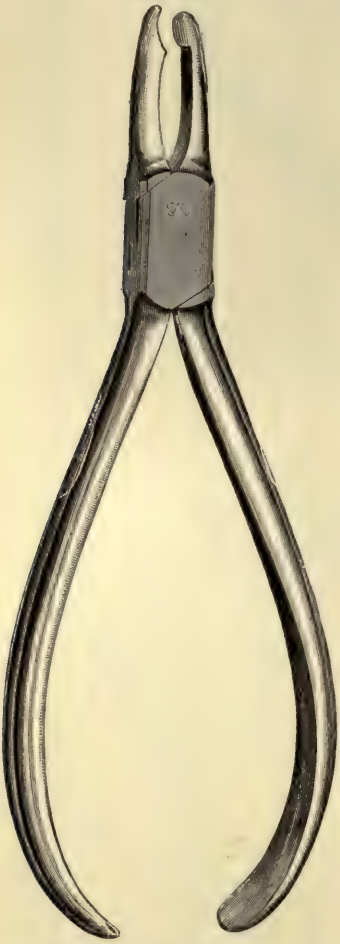
growing list of pliers designed for this purpose. The two forms figured subserve all the needs—one the form known as the Johnson pliers (Fig. 761). The curves of short radius may be given collars with these. The second pair is made by bending the beaks of a pair of round-nose pliers (see Fig. 379); the curve given the jaws represents the average curve of the buccal walls of the natural teeth.

The contouring is done before the barrel has been removed from the model, as the cervix is held in shape by the plaster and the barrel suffers no change of shape at that part. The occluding teeth are varnished and oiled slightly, the barrel filled with soft plaster, and the occlusion made. When the plaster has set it is to be trimmed to expose the square shoulder made by the top of the band and scraped down uniformly to the thickness of No. 30 plate. Cusps and sulci are then carved in such a manner as to get the greatest amount of masticating surface and natural effect.

Natural teeth of the same class should form the models from which to copy.

The surface plaster at completion of the carving is short enough to allow for the thickness of plate used for the cap. The collar and plaster cusps are then imbedded in plaster to a level with the shoulder; when set, this plaster is cut to a tapering prism or a truncated pyramid (Fig. 761, *A*).

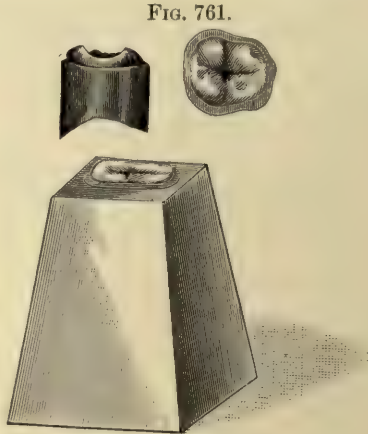
Fig. 760.



Varnish and make a Babbitt metal die; this, driven into a block of soft lead, makes its counter.

Annealed 22-carat plate, No. 29 gauge, is swaged between die and counter-die and the surplus gold × *B* trimmed off. The junction of this cap with the barrel forms then but a line; pickle the sections; apply borax to the inner surface of the cap and the top of the band; hold them in apposition with binding wire or between the jaws of self-closing pliers, and solder with 20-carat solder over a Bunsen flame. When finished there are but two faint lines representing the two joints of the piece (*C*).

Fig. 761.



The die for swaging the cap may be more quickly made with Dr. Mellotte's devices of tray, ring, moldine, and fusible alloy.

A small tray is filled with moldine, the surface of the latter is flattened; the plaster cusps are pressed into the moldine until the collar leaves a distinct and perfect outline. The rubber ring is placed around the tray, forming a well, the crown imprint in its bottom. A die of fusible metal is then formed. Another method almost exact is to fill the gold barrel with soft plaster or modelling compound while the barrel is in the mouth, and direct the patient to bite into it, then perform the movements of mastication. The crown is removed from the root, the plaster or modelling compound scraped away the thickness of No. 30 plate, and a die formed as above described.

These appliances of Dr. Mellotte are invaluable in many small laboratory operations.

But few of the many methods advanced secure the accuracy of adaptation of cap to root and of articulation which would warrant their general endorsement.

With a view to making an artificial crown what it should be, an instrument for the restoration of a lost function, it will be seen that accuracy of articulation is an essential. The exposure of the least surface of solder is desirable from æsthetic considerations.

Should it be desired to use this form in replacing bicuspids, porcelain faces may be attached after the following method, and the same may apply in making crowns for the anterior teeth containing vital pulp which it is decided to retain. The operation in nearly all cases up to and including the mounting of the articulation is the same.

The labial or buccal aspect of the band is to have a saw-cut made at the cervix, following the gingival margin, to the depth of the thickness of a plain plate tooth which has been selected—if a bicuspid, a cross-pin cuspid is used. Vertical cuts are made from the top of the band joining the saw-cut, detaching a section of the gold (Fig. 762). The tooth is

FIG. 762. FIG. 763. FIG. 764.

ground to make a perfect joint at the cervical shoulder and to fit the lateral walls of the barrel (Fig. 763). The tooth is bevelled for one-fourth of an inch or less at the cutting edge, and a stay of 24-carat gold No. 29 fitted to extend to all edges of its back (Fig. 764). This stay makes a close joint with the sides of the barrel. The pins are to be split. Pickle, unite tooth and barrel with adhesive wax, and invest in sand and plaster, so that the investment represents an open tunnel (Fig. 765).

FIG. 765.

Remove the wax, apply borax along the joints and around the pins, use four minute pieces of solder, one at each lateral joint, one over each pin; heat gradually to a red heat; then turn the fine blowpipe flame into the tunnel and unite the parts. The subsequent making of the cap is as described for the all-gold crown; it extends to the top of the backing, which is at the cutting edge of the tooth.

Prepared for soldering, the cap is waxed to the band, and the piece invested in sand and plaster, cap down, so that the interior of the crown represents a well in the centre of the investment; the investment over the cap should form but a thin layer.

Solder sufficient to fill the joints well is boraxed and placed in the

cap. The piece is heated. Transferred to the charcoal, the blowpipe flame is directed against the base of the investment until the solder flows. When cool it is boiled in acid, and every joint is dressed down with small files and corundum pencils until smooth; then buffed, burnished, and polished (Fig. 766).

Fig. 766.

A similar process may be used for the anterior teeth, as described on p. 618 for those cases in which it is thought advisable to retain a vital pulp.

Occasionally, where there is not a sufficient amount of a broken bicuspid extending above the gum line to afford adequate support to a collar crown, a post is attached to either the root itself or made part of the crown. If anchored in the root, the pin is made after the form of an inverted U, and securely fastened by means of amalgam. If it is designed to attach the pin to the crown, the pulp-canal is enlarged for half its length; if the root has a bifurcated or double canal, the palatal root is reamed out to that depth. An iridio-platinum post is set in the canal and the collar adjusted. A wax-bite and plaster impression are taken, a model and articulation made. The collar face is cut out for the reception of the porcelain tooth, and the post is loosened from its plaster canal. The facing is fitted and a stay adapted; adhesive wax unites the facing to the collar and the post to the backing stay. The pieces are next withdrawn, invested, giving the investment the tunnel form of Fig. 766, but the investment is carried over the pin sufficiently to hold it. The cap is formed and fitted as described, attached to the collar and facing by means of wax, and invested in an inverted position, carrying the investment up on the pin, but leaving space enough between the post and palatal portion of the collar to permit the ready introduction of the solder. The investment overlying the cap should be thin. When this has set the wax is removed; a liberal amount of borax and sufficient solder are applied to fill the cap. The piece is heated and the solder flowed by directing a flame against the base of the investment.

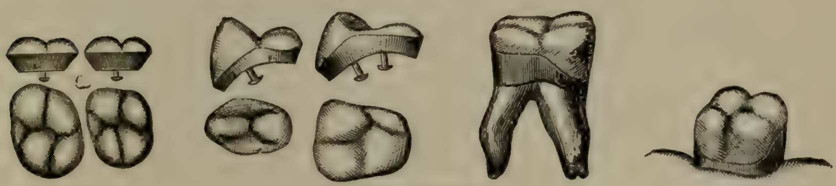
Another method of attaching porcelain facings to the gold barrel crown is by making the entire crown first of gold, the barrel and articulating surface complete. The external wall of the crown has the segment made visible by the movements of the lips sawn out, and the cut edges of the metal bevelled. A porcelain facing is selected of a size to fit the space with the minimum grinding. It is to be ground in until all of its edges fit those of the barrel. A stay of No. 34 pure gold is burnished over the back of the porcelain tooth. The edge of the stay should be accurately adapted to the barrel. The crown and facing are cemented together with adhesive wax, covered by a thin investment and soldered by means of a blowpipe flame directed against the portion of the investment covering the facing.

Fig. 767.

The buccal and articulating faces of molars and bicuspids may be made of porcelain, the attachment of the crown to the root being secured by means of a gold barrel. The barrel is made as for an all-gold crown. A wax-bite and impression are taken, and an articulation mounted. Before cutting away the buccal wall of the barrel for the reception of the porcelain, measure by means of a wire and

dentimeter the circumference of the upper portion of the barrel. The loop made is taken to the dépôt, and a saddle-back or a plain rubber tooth is selected, the circumference of which agrees with that of the barrel (the wire loop). The tooth should have but little thickness of porcelain above the pins (Fig. 768); the S. S. W. cusp crowns are designed for

FIG. 768.



Cusp crowns.

this special use. A scratch is made along the buccal portion of the barrel, marking it slightly above the gum line and between the adjoining natural teeth along the line of exposure. A fine saw is used to cut away the buccal walls to these lines. The palatal wall of the barrel is cut down if necessary to admit the face, so that it will articulate with the antagonizing teeth. Should there be any lack of correspondence between the outlines of the barrel top and the cusp crown or tooth, the gold is bent to fit the latter accurately. By means of fine-grit corundum wheels the edges of the porcelain are closely adapted to the cut edges of the gold at the cervical and approximal borders, and articulated perfectly with the antagonizing teeth. The tooth and barrel may now be set with cement: it is preferable, however, to solder the porcelain to the barrel. A piece of 24-carat gold No. 33 is fitted as a stay to the under surface of the porcelain and burnished into accurate contact. The tooth and stay are set in the barrel, and the latter is cut away at points interfering with its correct placement. It is boiled in the acid solution, and invested so that the interior of the barrel and the stay exposed form a well. Borax is painted around the line of junction and over the pins, a small piece of solder placed over each pin, and three or four pieces around the joint, and the piece is gradually raised to a high heat; a fine flame directed into the well fuses the solder, uniting the pieces perfectly.

In finishing the crown the gold should be dressed down to the porcelain, making a perfectly smooth joint. No projection of the gold beyond the surface of the porcelain should remain.

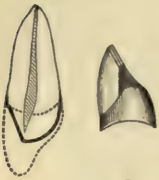
Fused porcelain may be used in lieu of solder to attach the crown to the barrel, as described by Dr. Robert Huey:[1] "The barrel is fitted and cut out as described. One of Ash & Sons diatoric teeth is selected and fitted to the barrel. Openings are drilled through the mesial and distal walls of the barrel, which shall exactly uncover the openings of the tube in the tooth. A piece of platinum wire is thrust through holes and tube, holding the porcelain to the gold. The platinum wire is now either riveted or soldered to the barrel. The line of junction between gold and porcelain is painted with a paste of dental glass, which is then fused in a Downie furnace."

[1] Penna. State Dental Soc., 1896.

Porcelain-faced Crowns for Teeth containing Vital Pulps.

When collar supports are to have porcelain faces, those cases where crowns are to be placed over teeth containing vital pulps, the tooth to be crowned is to be trimmed so that a sufficient covering of dentine is left to act as a protector to the pulp. At the labial or buccal aspect the tooth is sloped to the gum margin, carefully avoiding uncovering the cornua of the pulp (Fig. 769, *a*). The root is trimmed for the reception of a collar, which is fitted and permitted to project about one-sixteenth of an inch above the edges of the tooth. The parts of the band in contact with the antagonizing teeth when the jaws are closed are ground to about one-sixteenth of an inch short of occlusion. The labial portion of the band is cut away, following the slope given the labial aspect of the tooth and level with it. A cross-pin tooth is carefully adapted to these edges. The palatal surface of the porcelain tooth is given a long bevel toward its cutting edge. A stay of No. 27 plate is closely adapted to the tooth, its lower edge in contact with the collar (Fig. 770). The tooth and barrel are invested; the pins are soldered to the stay, and the stay to the collar. The crown in this condition is transferred to the model and the articulation noted. If the collar is almost in contact with the antagonizing teeth, its palatal surface is formed of a single piece of plate bent to conform to the open top of the collar, and as far up on the stay as the bite will permit. It is desirable, where possible, that the stay should be made double throughout.

Fig. 769.



a *b*

Fig. 770.

Should there be a necessity for contouring the palatal surface of the crown, the articulating teeth are varnished, a batter of plaster is placed in the collar and over the stay of the crown, and the articulation closed. The plaster is, when hard, scraped down uniformly to allow for the thickness of the piece to be added—No. 30 plate. It is then carved to the desired form, freeing from plaster the edges of stay and collar. A small die is made of fusible metal poured in moldine and a cap swaged. The pieces are boiled in acid. The surfaces to be united are touched with flux wax and brought together, and the piece invested. Along the joint—or, rather, beneath the joint on the collar—three small pieces of solder are placed, one in the middle, one on each side. In soldering direct a fine flame beneath the joint, never on the cap, as, this being the portion most readily heated, the solder has a tendency to run from the collar to the surface of the cap. In finishing such caps each edge should be carefully rounded.

Application to Abraded Teeth.—This form of crown is frequently applicable to abraded teeth. The remaining teeth of a denture being worn down to within a short distance of the gum line, it becomes necessary to protect each tooth from further progress of this formidable destruction. Each remaining tooth is to have its crown length restored by the substitute. The molars and bicuspids are covered by all-gold crowns; where possible the anterior crowns are made with porcelain faces, without destroying the receding pulps.

It is advisable, first, to make and set three crowns—one on each side and a central incisor: these fix the bite in its altered relations; the remaining crowns are then fitted and adjusted in pairs.

Post and Collar Crowns (Richmond Crowns).

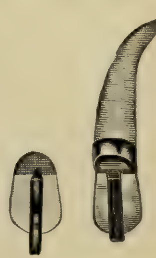
When it has been determined that the use of a band upon one of the anterior teeth is desirable, whether from undue loss of tooth-substance or because an unusual stress is to be borne by the root, the Richmond or collar crown is the one commonly employed.

A band is made to fit the properly shaped root according to the method described. This is placed on the root, and is trimmed a little below the margin of the gum. At the palatal aspect the trimming need not be so deep. The curve at the cervix should be the same as that of the adjoining tooth (see Figs. 722, 723), so that in the completed crown the cervical outlines may be alike. The collar is then removed, pickled, and

Fig. 771.

its upper surface laid upon a flat piece of 24-carat gold plate No. 31, the points of junction boraxed, a minute particle of solder (22-carat) placed at the junction; the plate is held over a Bunsen flame until the solder flows and fixes the band at one point. The plate is then bent down to fit the entire edge outline of the band, and soldered as before, using a piece of solder of the size of a pin's head for this purpose. The cap is then trimmed, placed in position upon the root, an opening made uncovering the root-canal, and a pin which has been fitted thrust through this opening into position. Withdraw the post, and, if the collar comes with it, unite them with a small piece of 18-carat solder; the soldering may be done over the Bunsen flame. As a rule, it is necessary to unite the wire and cap by means of adhesive wax to enable the operator to withdraw both pieces together. They are to be invested, and the post attached to the cap with a small piece of solder. Place the post and collar in position, and take a wax-bite and plaster impression as for the post and plate crown. The subsequent operations are the same as those in making the latter forms of crown. (See *ante.*)

Fig. 772.



The three varieties of crowns described are those which are commonly and most acceptably used as supports in bridge-work.

A removable porcelain facing to place upon a post and collar base has been devised by Dr. W. L. Mason of Red Bank, N. Y.[1]

The post and collar are made as described. Dr. Mason's device consists of two pieces—one a drop-forged backing of heavy gold plate, which has a triangular slot throughout its length,

[1] *Dental Cosmos*, Aug., 1896.

the base of the triangle in the body of the backing (Fig. 772). The second piece is a porcelain facing, having baked in the longitudinal axis of its lingual face a triangular platinum bar, which readily slips into the slot of the backing. A portion of the post extends beyond the cutting edge of the tooth. Both teeth and backings are made in standard sizes and forms.

The tooth is slipped into its backing, and both are ground to fit the ferrule tops. The backing is attached to the ferrule by means of hard adhesive wax. When the latter is hard, the platinum extension is grasped and the tooth withdrawn from the backing; the metallic pieces are next invested and united to one another by means of solder. The piece is now chilled, smoothed, polished, and adjusted to the root. The lingual surface of the tooth and the platinum are to be covered with a thick solution of chloro-percha and slipped into position; the protruding platinum is sawn off and the edges of the metal are burnished.

Ready-made Crowns.

Of the ready-made porcelain crowns there are two varieties—first, those designed for fixation upon a post which is previously fastened in the root; second, those having a pin baked in them. To the first class belong the Bonwill, the Foster, and the How; in the second class are included the Logan, the Brown, and the new Richmond crowns. Crowns which are formed and adapted by means of sets of ready-made appliances, such as the Hollingsworth and the mandrel systems, belong to the class of built-up crowns. The crowns of How and of Brown are no longer manufactured.

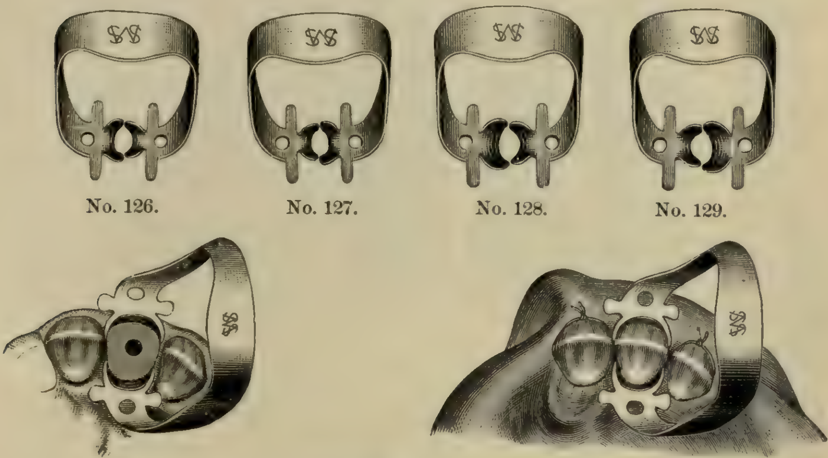
Of all the ready-made porcelain crowns, that offering the widest range of application is the Bonwill. It is made entirely of porcelain, and is perforated for the passage of the supporting post (Fig. 773). At its bases it is concave, the upper portion of the perforation formed into a shape which prevents the displacement of the crown after it is fixed upon its post.

Fig. 773.

The edges of the porcelain are designed to rest uniformly upon the outer edge of the prepared root-surface. An eminently satisfactory method of fitting these porcelain crowns is as follows: After the root face has been trimmed as for the reception of any post crown, take a wax-bite of the side having the crownless root, and then a plaster impression. In the plaster impression a model of fusible metal, one melting at about 150° F., is poured. A shade tooth is selected, and an articulation mounted. A crown of the proper form, shade, and size is selected. Select one the base line of which corresponds closely with that of the root outlines represented in the model. By means of fine-grit corundum wheels the crown is well adapted to the edges of the root face and correctly articulated with the antagonizing teeth. In adjusting these, and indeed all post crowns where the roots can be grasped firmly by them, the Ottolengui root clamps are invaluable (Fig. 774, Nos. 126 to 129). A pin of the largest size admissible (Fig. 776) is set in the root-

canal and the crown set in position over it (Fig. 775). Should there be lack of correspondence between the directions of the root-canal axis and

FIG. 774.

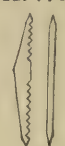


Root-clamps for crown-work.
Devised by Dr. Ottolengui.

the perforation of the crown, the post is to be bent and filed until the crown slips readily over it, the palatal wall of the tooth perforation resting against the post. The latter is withdrawn from the root, and by means of a small wheel bur the walls of the root-canal are cut to a semblance of a screw thread.

FIG. 775.

FIG. 776.

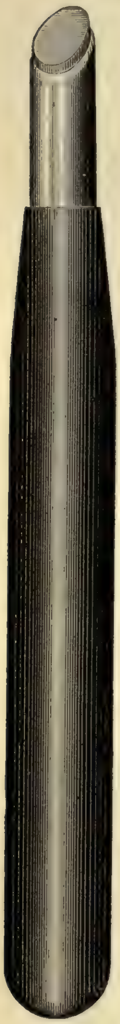


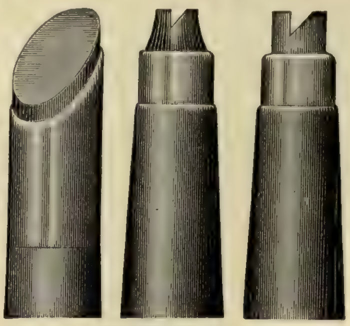
After the crown edges have been adapted to the root face, a small corundum point is passed around the basal concavity of the crown, removing sufficient amount of the porcelain to give almost a feather edge. This is to prevent the amalgam at the junction from being reduced to a thin sheet, which might be broken, forming a space at such points in which fermenting materials might find lodgement.

Slow-setting zinc phosphate is mixed and a small pellet carried to the end of the root-canal, and the post pressed firmly into it; the crown is then passed over the post into its proper position and permitted to remain until the cement is hard. The crown is removed and soft amalgam is packed about the pin and root-canal walls for about half the length. The remaining amalgam is wrung out to remove the excess of mercury, and packed in small pieces about the post. Place the crown over the post for assurance that the post has not changed in position. In packing the amalgam a more homogeneous mass is made by using pellets of bibulous paper, as recommended by Dr. Bonwill, to compress the mass and force out the surplus mercury. A fresh mix of amalgam, wrung half dry, is banked up about the post, and when more than enough to fill the concavity in the base of the crown has been so

packed, the crown itself is firmly and steadily pressed into position by means of an appropriate crown-driver until the junction of the crown and root is represented by a faint blue line. Amalgam, mixed very dry, is now packed about the end of the pin in the cavity of the articulating face, using bibulous paper to express any free mercury; when this cavity is more than full sponge gold is rubbed into the amalgam until it ceases to be amalgamated, when the surplus is removed, dressing the amalgam flush with the crown surface. If the amalgam employed contains at least 60 per cent. of silver, and cut in fine grains, it will be well hardened at the end of the operation described. It must be well hardened before the crown is subjected to the stress of mastication; otherwise the crown will be displaced. The writer occasionally defers the packing of the amalgam about the end of the pin to the next day, filling the articulating surface cavity with zinc phosphate, permitting this to set and hold the crown in position for twenty-four hours, so that the amalgam supporting the crown may set perfectly before any force is applied to it. The cement is subsequently removed and its place filled with soft amalgam, which is well compressed by means of bibulous paper; the soft portions of amalgam then cut out, and the filling completed with dry amalgam, packing more than full, then cutting it down to the surface of the tooth.

Fig. 777. Fig. 778.





Crown adjusters.

In applying this crown to the restoration of molars a post is to be used in each root. For the upper molars a large-sized post is used in the palatal root, and smaller ones in the buccal roots. These may be fixed in position by means of zinc phosphate to hold their distal ends, as described above.

Fig. 779.

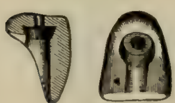
Fig. 780.

The How screw posts will be found frequently applicable with the Bonwill, as with other crowns of the same class. The Gates, Foster, and How dovetail crowns are all of analogous forms, and are to be attached in the common method, a screw anchored in the root, which has been drilled and tapped to receive it, amalgam filling every remaining space in the root and crown and also between them. Their mode of application is seen in the illustrations.

The all-porcelain crowns, such as the Foster, Gates-Bonwill, dovetailed crown (Figs. 781 to 783), and others, have been set in various ways, prominent among which has been the use of solid-headed screws; but

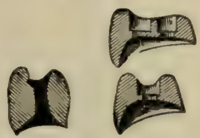
firmer and more satisfactory work can be done by first fixing the screw-post in the root (Fig. 785), thus permitting the crown to be slipped over the end of the post and properly adjusted to the root, after which the cavities in both root and crown may be partly filled and a nut

Fig. 781.



Foster crown.

Fig. 782.



Gates-Bonwill crown.

Fig. 783.

Dovetailed crown.

screwed on the end of the post to condense the filling and firmly secure the crown in its place. These appliances are very simple. They consist of a nut-driver, over which is placed a split tube for carrying the nut. (See sectional view, Fig. 784.) The sole object of this tube is to

Fig. 784.

AA A B
How screw-posts
(A, with nut).

Nut-driver with split tube.

AA A B
Headed screws.

hold the nut and prevent its falling into the mouth or on the floor during the process of attaching or detaching it from the post.

The nuts and nut-drivers are made of three sizes to suit the How screw-posts AA, A, and B, and the old form of headed screws, which are made of the same sizes as the How posts with nuts. Fig. 785, A and B, illustrates the application of the double screw in connection with molar crowns.

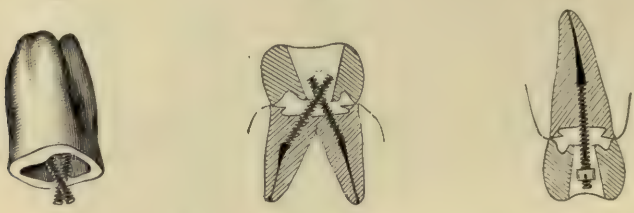
The next class of crowns is composed of those having their platinum posts baked in them: they are the Logan, the Brown, and the new Richmond crown.

The first of these has the widest range of application, and is the form in most general use. Being composed of porcelain alone, and having no underlying mass and backing of metal, they present a translucent appear-

ance not to be had with those forms of crown which are built up in part of metal. An excellent method of selecting and adapting these crowns

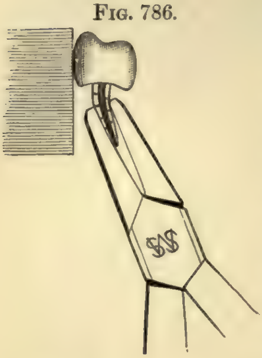
Fig. 785.

A B C



is as follows: The root face is trimmed by means of rotatory files or the Ottolengui root-facers to the level of the gum margin. The canal is sterilized, and the upper third hermetically sealed, the remainder of the canal enlarged to about one-sixteenth of an inch in diameter. A wax-bite is taken, including several of the adjoining teeth. A piece of iron wire one-half of an inch longer than the reamed portion of the canal, and small enough to slip very freely in it, has its end bent into a loop and the canal portion covered with gutta-percha, which is then oiled and slipped in the root. A plaster impression is taken in which the coated wire is withdrawn, and a model made of fusible metal melting at about 150° F. A shade tooth and a crown corresponding with the natural teeth are selected. The direction of the axis of the root-canal is noted, the angle which it makes with the root face, and compared with the direction of the axis of the selected crown: not infrequently it is necessary to bend the pin at an angle with the axis of the crown itself (Fig. 786). The opening in the root, made by withdrawing the gutta-percha and wire, is enlarged sufficiently to receive the post of the crown.

Fig. 786.



The pin is bent, if necessary, so that the axis of the crown is parallel with that of the natural fellow, bringing the cutting edge of the artificial crown in the arch of the natural teeth. The points of contact between the edges of the crown and the face of the root represented in the metallic model are ground from the porcelain until there is a uniform contact throughout the crown edge. The grinding is done by means of square-edged corundum wheels on a laboratory lathe or by an engine wheel, as shown in Fig. 787. The cutting edge of the artificial crown should exactly repair the break in the arch. Its palatal surface is cut away, if necessary, to articulate with the antagonizing teeth, in which event the cut surface should be smoothed and polished. The canal is enlarged by means of fissure burs or Ottolengui's reamers (Fig. 788) until the pin slips readily into place and the surfaces of crowns and root are in contact. Should either the edge of the crown or the edge of the root project beyond the common line at any point, it is to be trimmed down

until the line of junction is uniform. Any slight imperfections of contact are to be remedied by means of the carbon-paper test: small pieces of this material, large enough to cover the face of the root, are pressed

FIG. 787.

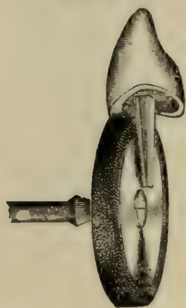
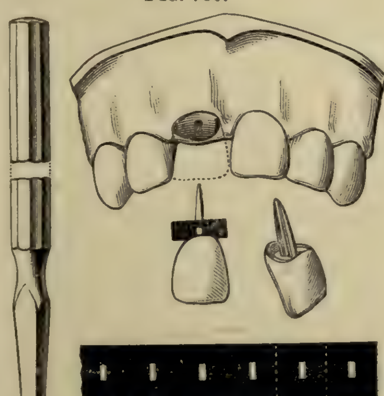


FIG. 788.

to its surface and perforated by the crown post. The crown is now pressed firmly into position and withdrawn: should there be any breaks in the black line, the crown is dressed down at all parts marked until there is a continuous black line at the outer edge of the crown.

The crowns may be accurately adapted to the roots without the use of a model, but, as it is desirable to make a model to serve as a guide in selecting a crown of the proper size and form, the same model may furnish a base and guide for adapting it. The operation described in reality saves time.

FIG. 789.



Punch for making holes in articulating paper.

Prepared articulating paper.

In fitting these crowns without a model the canal is enlarged sufficiently to receive the metallic post, the root surface trimmed to the proper form by means of the root-facers, and the crown is fitted as follows:

Dr. E. C. Kirk's Method of Fitting a Logan Crown to a Tooth-root.—Cut several small pieces, about one-quarter inch square, from a strip of thin articulating paper. In the centre of each punch a hole with the tool shown in the margin. Having prepared the root-end, slip the perforated piece of articulating paper over the pin of the Logan crown and

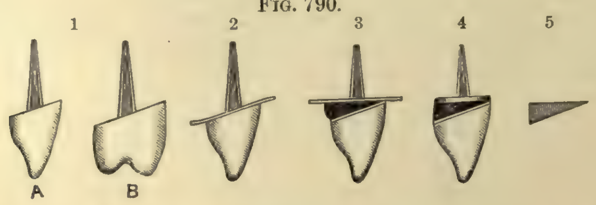
press it firmly into position, in contact with the root. Upon withdrawing the crown and removing the articulating paper, the points of contact will be found to be marked black. Grind these off carefully, readjust on the root as before, grind again, and continue the operation of fitting and grinding until the mark made by the articulating paper on the contact surface of the crown presents as a uniformly unbroken black ring. When this has been accomplished, the crown will be found to fit the root-end with the utmost accuracy. The advantages of fitting a crown directly to the root are, it would seem, self-evident from the mechanical standpoint, and involve besides the least expenditure of time.[1]

A Method for Perfectly Adjusting the Logan Crown.—"By making a considerable change in the present form of the Logan crown, as shown in Fig. 790, 1, *A* and *B*, we have a crown that can be adjusted in a few minutes, and with a degree of perfectness not yet obtainable by any crown on the market, nor, within my knowledge, by any so far suggested method.

"The manner of making the adjustment is certainly as simple as could be desired.

"After preparing the canal for the reception of the 'Logan pin,' select a tooth in the usual way, having regard to correct length, width, and color, and if care has been exercised to select one as near the right length

Fig. 790.



as possible, it will only be necessary to touch the buccal or labial point of the neck of the crown a few times with the corundum wheel, and the proper length or bite will be obtained. Next take a disk or small piece of thin platinum foil, about No. 50, and push through this the pin of the tooth, carrying the disk up against the porcelain, as represented in Fig. 790, 2. With a little drop of Parr's fluxed wax dropped in the triangular space, formed by the backing and the pin, the disk is held securely in place, and the platinum is trimmed around with small scissors, that there may not be any overlapping. Now place around the pin on the platinum a ball of Parr's wax, stick the pin through the second disk of the foil, and rub the platinum with a hot instrument, that the wax and disk may be sealed together, as shown in Fig. 790, 3. Place this in ice-water to harden the wax, so as to resist pressure. It is now ready to insert, and by pressing the tooth up until the labial surface strikes the end of the root, and having the patient to close the jaws, the correct bite will be secured with the opposite tooth. It will be found on the removal of the crown that the platinum next the root has been perfectly swaged to the root-end. This second disk is now trimmed according to the outlines of the root. When it is so desired, the palatine side of the root having been left a little high, or just above the gum, the platinum can

[1] *Dental Cosmos*, June, 1894.

be split with scissors, lapped, and burnished around the exposed side of the root, to form a partial band (Fig. 790, 4).

"After having dried the wax with bibulous paper and shaped up the approximal sides, these sides are covered with small, triangular pieces of platinum (Fig. 790, 5) by lapping the platinum on the wax and rubbing over it a hot burnisher. The crown is now ready to invest, and the investing mixture is poured on a small piece of wire netting, which will prevent its cracking during the soldering operation. The wax having been burned out, this triangular box is filled flush with solder in the usual way and polished. The result is a beautiful and perfect crown, in every respect the most substantial porcelain crown we have.

"I frequently make the crown without using the triangular piece of platinum to form the box (Fig. 790, 5), relying on the investment to form the sides. This saves a little time; but it frequently happens, unless care has been taken to make the wax flush, that the approximal surfaces are not well rounded, and consequently do not finish well. It is therefore safer to use the triangular pieces of platinum foil to form the sides of the box, as described, before filling with solder. This plan is particularly adaptable to those cases of fracture which have resulted in a rough root-end, and where it is often next to impossible to get them smooth.

"Where it is convenient or if it is desired, the triangular box can be filled with 'body,' and baked in a Parker furnace from six to eight minutes. This gives us an all-porcelain crown which fits perfectly to the end of the root. In this case the first disk next the porcelain is left off entirely."[1]

CAUTION.—The Logan crown contains a large tapered pin with its large end baked in the tooth, and when heated to flow solder over or around it, care must be taken that the porcelain is made as hot as or hotter than the pin, thus preventing uneven expansion and cracking of the porcelain.

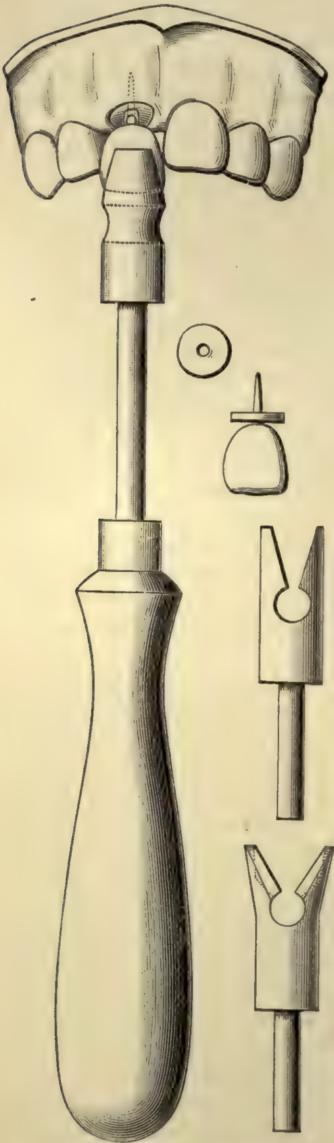
These crowns may be adapted upon frail roots, those which demand the supplementary support of a band encircling their necks. It is a matter of but little practical moment whether the collar is or is not attached to the crown: the object sought, the protection of the root against longitudinal fracture, is secured by banding the root first, forming an artificial root face by means of metal. The root face is trimmed as for a collar crown; the collar is fitted and a cap soldered to it, the edge of the top being hidden at its labial aspect by the gum. While the cap is on the root an opening is made in it considerably larger than the size of the crown post. A piece of metal longer than, and slightly larger on its sides than, a full Logan post is greased with vaseline; the root is dried, zinc phosphate is packed into it for more than half its length, the ferrule partly filled by the same mixture and pressed into position. While the cement is soft the metal wedge is thrust into the cement as deep as a Logan pin, and left until the cement hardens, when it may be readily withdrawn. The crown is now adjusted to the canal in the cement and to the edges of the ferrule top. The gold of the cap may be dressed away, together with a portion of the cement, until but a narrow retaining rim of gold is left.

Logan crowns adapted after this manner are to be cemented into

[1] Gordon White, D. D. S., *Dental Cosmos*, January, 1893.

position as follows: An appropriate root clamp (Ottolengui's) is placed on the root, and the rubber dam slipped over several adjoining teeth and the clamp. The root is well dried by means of alcohol and the hot blast; the canal is wiped with a pellet or cone of paper saturated with the cement fluid to facilitate the flow of the cement. A paste of cement is made just thick enough to be formed into perfectly plastic pellets; one of these is rolled into a cone, and before the latter bends by its own weight it is carried into the canal: another is pressed into the concavity in the base of the tooth; the grooves in the post are filled; the crown is then thrust into position and pressed home, when the cement will ooze from the edges, and the joint should be a very thin line. The crown is left undisturbed for at least fifteen minutes, when the cement will be found hard enough to resist fracture.

Fig. 791.



Logan crown with gutta-percha.

The advantages possessed by cement, hardness and rigidity, may be combined with the virtue of gutta-percha, insolubility in the fluids of the mouth, after the following method:

"First prepare and treat the pulp-canal of the natural tooth-root in the ordinary way, the canal being provided with undercuts or retaining points, and fit the crown in proper alignment with adjacent teeth as usual. Fill the cup or recess in the neck of the porcelain crown with gutta-percha, which can best be accomplished by slipping a washer or perforated disk of gutta-percha, cut to correspond approximately with the size of the neck of the crown, over the crown-pin, and after softening by holding it in the flame of a burner, press the crown to its place upon the root. After it has been held in position until the gutta-percha has cooled, remove the crown from the root and trim off any surplus gutta-percha. Now coat the end of the root with shellac varnish, fill the root-canal with a suitable amalgam or cement, or, if preferred, pack it with prepared gutta-percha points, using such an amount of points as will allow the crown-pin to enter the canal not quite the full length of the pin. The opening for the pin in the gutta-percha in the canal may be made with a heated instrument having a tapered

point. Having packed the crown-recess with the proper quantity of gutta-percha, as above explained, place the crown in position in the mouth, heat the copper end of a crown-setter sufficiently to soften gutta-percha, and place the grooved end of the setter over the crown with the heated copper in contact with the porcelain. Hold the setter against the crown until the gutta-percha becomes soft, when pressure should be applied to the setter and the crown with its pin forced to its proper position. After the gutta-percha becomes cool, which can be hastened by dipping the crown-setter in a tumbler of ice-water and holding it against the tooth until it is cold, cut off any surplus that may be squeezed out from between the crown and root, with a sharp knife, and then with a hot tool smooth the edge of the gutta-percha between crown and root. If the cutting is attempted while the gutta-percha is soft, it will be dragged out of place.

"The use of gutta-percha for packing the root-canal, thus making the entire attachment with this material, possesses the advantage over the use of cement or amalgam in that, should the root become abscessed, the crown may be removed with a pair of forceps after first heating it with the setter, the root-canal treated until the disease is cured, and the crown reset. Heating the porcelain crown when a cement is used to fill the root around the pin hastens its setting. Do not heat the crown if amalgam has been used."

Banding Logan Crowns.

There are several methods of banding the Logan crown, so that the ferrule becomes an integral part of the crown. One method of making the attachment is as follows: Adapt the collar to the root, and fit the cap inside, not over the band, soldering with 22-carat solder. Fit the Logan crown to the ferrule, perforating the latter for the passage of the post, which should be grasped tightly by the cap. At the palatal side cut out the porcelain for about one-sixteenth of an inch, leaving only the labial crescent of porcelain in contact with the ferrule. Perforate a circle of 24-carat gold No. 40, and pass over the pin and burnish into the concavity in the base of the crown. Perforate other pieces of thicker gold and pass over the post, pressing them firmly into contact with the pieces previously placed, until the concavity is filled and the last piece extends to the palatal edge of the crown. The pieces are covered by Parr's adhesive wax; the same material is flowed over the top of the ferrule and the crown pressed into position; the crown and ferrule are placed on the root and adjusted to position; the wax is chilled by having the patient hold ice-water in his mouth for a few moments. An excavator point is passed beneath the upper edge of the collar, and it is withdrawn and invested. The wax between the last, the broadest piece of gold, and the ferrule top is picked away and small pieces of gold are used to fill the space. A liberal amount of 18-carat solder is laid over the gold, and the case heated under the blowpipe, directing the flame against the investment over the labial portion of the crown, drawing the solder through from the palatal side, adding more solder if necessary to fill the joint flush.

Dr. Townsend's method of attaching a band without the top is appended:

How to Band a Logan Crown.—"Prepare the root as usual for a band crown, and enlarge the root-canal to receive the Logan pin. Grind a Logan crown to fit and articulate it. Construct a band of No. 30 gold (or of No. 32 crown-metal, which is better) wide enough to project beyond the end of the root, say three thirty-seconds of an inch. Cut a wooden peg about an inch long, and taper one end of it to the general size and shape of the pin in the Logan crown. Place the band on the root, insert the peg in the canal, and fill up the band with Melotte's moldine or with stiff putty, pressing it closely about the peg. Remove all together, and, holding the die over the flame of an alcohol lamp to melt the fusible metal, place them—the band, peg, and moldine, in the same relative positions they occupied in the root—on the die, with the pin in the socket, and press down until the moldine rests on the surface of the molten fusible metal. Chill; in cooling, the fusible metal takes a firm hold on the lower edge of the gold band, holding it securely in place during the remainder of the operation. Remove the peg and the moldine, and with a wooden mallet drive the Logan crown into the band until the porcelain rests upon the fusible metal. Burnish the band smoothly about the crown. When the gold is perfectly adjusted to the porcelain melt the fusible metal to release the band and crown. If the work has been carefully done, the crown with its band will then be ready to be set, as the articulation and fit will not have been disturbed."

Fig. 792.

1, socket; 2, fusible metal.

Method of Mounting a Logan Crown with a Gold Cap.—"With regard to crowning teeth, some have no doubt met with cases like the following, where ordinary methods are not available: Miss L—— called at my office to have a lower right first bicuspid crowned. There was a considerable portion of the lingual part of the crown standing, the buccal surface being decayed almost to the gum-margin. The coronal portion of the pulp was calcified, and she objected to having it destroyed, nor did I think such a course necessary. Here an all-gold or even porcelain-faced crown would have been too conspicuous, so I decided to apply a Logan crown,—*not*, however, with its ordinary pin, but with a cap and collar. I trimmed the root, leaving the lingual side a little high, and took a model and bite of it. A cap and collar were made to fit the root accurately and *tightly*. A suitable Logan crown was next selected, and the pin cut off. Into the countersink and around the stump of the pin I *flowed pure gold*, and then proceeded to fit the crown to cap and bite. A hole was next cut in the cap, and enlarged till it nearly corresponded in size to the gold base in the countersink of the crown. Cap and crown were now waxed together, and invested crown downward in plaster and marble-dust. This left the interior of the cap and band exposed, and through the aperture in the former all except the edge of the pure gold could be seen. The wax was then removed and the whole soldered. A

slight groove was cut round the remaining portion of the root to assist retention, and the crown was cemented in place."[1]

Another method is appended, the principle the same as the first described:

Dr. Hollingsworth's Method for Accurately Adapting and Mounting a Logan Crown with a Band.—"Prepare the root in the

Fig. 793.

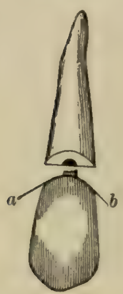
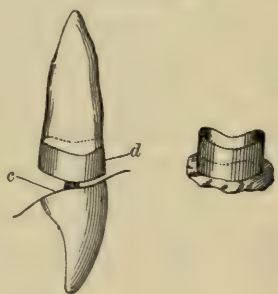


Fig. 794.

Fig. 795.



usual way for banding. (See Fig. 793, front view, and Fig. 794, side view.)

"Grind the abutting surface of the crown to fit the root under the free margin of the gum, along the labial face *only*. (See Figs. 793, 794, *a* to *b*.)

"Cut the crown away slightly at the lingual surface, so as to leave a space between it and the end of the root. (See Fig. 795, *c*.)

"Make a band only wide enough to give a good hold on the root, but not to extend beyond margin of gum to fit the root and trim off even with the end of it. (See Fig. 795, *d*.) After fitting the band properly, remove it and solder a piece of pure gold plate, say about No. 34, on the outer end. (See Fig. 795, *e*.) This can be done quickly by placing the plate in the hand and pressing the band on it with the thumb for a fit, then soldering in the flame of a Bunsen burner. Punch a small hole through the plate to take the pin in the crown, and replace

Fig. 796.

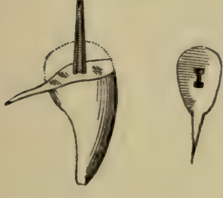


Fig. 797.

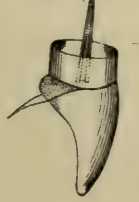
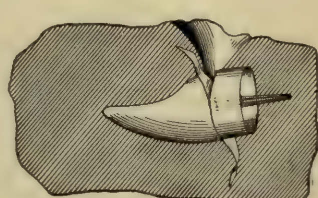


Fig. 798.



in position on the root after trimming off the exposed edges. Now take a piece of thin pure gold, say No. 34 or 36, with ears as shown in Fig. 796, *f*; punch a hole through it, slide it over the pin of the Logan crown, and burnish tightly to the base of the crown. (See Fig. 796, *g*.) Next

[1] Dr. Girdwood, *Dental Cosmos*, January, 1894.

warm the pin and place a sufficient quantity of Parr's fluxed wax around it as shown by dotted lines, Fig. 796. Replace the Logan crown on the root (with the cap in position), force home until the labial edges of root and crown meet, obtain the proper alignment, and cool and harden the wax by using a napkin with ice-water. Then remove the crown and cap together, held in proper relative position by the wax. (See Fig. 797.) Trim off the surplus wax and invest. (See Fig. 798.) Remove all the wax possible between the crown and the band, and flow 20-carat gold solder into the space. The wax which will necessarily remain, being fluxed, will carry the solder into every crevice and give the crown great strength. Finish the band and the soldered edges, and the result will be a strong and perfectly aligned crown.

Brown Crown.—This crown is made with a curved base, reducing the risk of fracture of the crown itself. The canal is reamed for the reception of the post. It is very difficult to adapt this crown with great accuracy. The root is more readily formed to receive the crown than is the crown to fit the root face. A crown of the exact size, shape, and color of its fellow is selected. A Willard countersinking bur (Fig. 799) is employed in cutting away the points of contact with the crown base. If it be necessary to trim the crown base itself, it is most readily done by means of a diamond disk having a safe edge. If the canal have been reamed out so that the post fits the canal snugly, these crowns may be set with gutta-percha.

FIG. 799.

This variety of crown, owing to its great strength, is well adapted as an abutment crown of the all-porcelain bridge, crown and bridge both designed by Dr. E. Parmley Brown.

The New Richmond Crown.—The description of this special crown and its field of application are thus set forth by W. Storer How, D. D. S., Philadelphia, Pa.:

"The usual preliminary treatment of the natural tooth-root and the filling of the apical fourth part of the pulp-canal are predicated of all the cases which will here be described and illustrated, in exemplification of the preferred mode of mounting the new porcelain tooth-crown invented by Dr. C. M. Richmond.

"A superior left central incisor root will serve as a typical case, and its projecting end is to be shaped as seen in Figs. 800 and 801. This can be rapidly done with a narrow, safe-sided flat or square file, the angles of the slopes being such that the gum on the labial and palatal aspects will not interfere with nor be disturbed by the operator in this preliminary work, for the root-end is not at this time to be cut quite down to the gum. An Ottolengui root-reamer No. 2 is then employed to bore out the root to receive the crown-post, which is of the same size and shape as the Logan crown-post for a central incisor. Fig. 802 shows in section the relation of the reamer to the root. The new Richmond crown (Fig. 803) is then put on the root (see Fig. 804), and its position relative to the adjacent and occluding teeth noted. If the cutting edge of the crown is to be brought out for alignment with its neighbors, the root can be drilled a little deeper and the reamer pressed outward as it revolves to cut the labial wall of the cavity. The palatal root-slope must then be filed to make the V correspond to the changed inclination of the crown.

"Thus, by alternate trial and reaming and filing the crown may be fitted to the root and adjusted in its relations until the post has a close, solid bearing against the labial and palatal walls of the enlarged pulp-cavity, and the crown-slopes separated from the root-slopes by the thickness of a sheet of heavy writing-paper. This space can be accurately gauged and the root-slopes conformed to the crown-slopes by warming the crown and putting on its slopes a little gutta-percha, so that an impression of the root-end may be taken, and the root-slopes dressed with a file until the film of gutta-percha proves to be of equal thinness on both slopes. After thus completing the adjustment, with due attention to the alignment and occlusion, the crown and the root are to be dried as thoroughly as possible.

"To do this effectively in the root it should first be swabbed and washed out with absolute alcohol, and then continuously flooded with

Fig. 800.

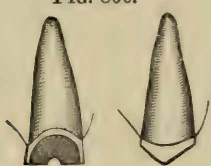


Fig. 801.

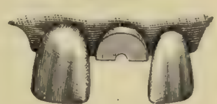


Fig. 802.

warm air, until the root is not merely dry, but dried throughout as far as possible, and made so warm as to render the patient conscious of its heat. A little gutta-percha is then put on the sides of the post and over

Fig. 803.

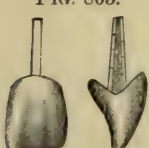


Fig. 804.

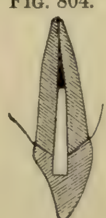
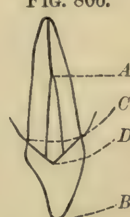


Fig. 805.

Fig. 806.



the slopes of the crown, which is then pushed into place, the exuding gutta-percha cut away, and the joint smoothed with a warm burnisher. The film of gutta-percha should be *very thin*. The crown and root may be quickly cooled by the use of the syringe with cold water, and the patient then enjoined to let the crown rest for a few hours in order that the gutta-percha may become quite set. Fig. 805 shows the completed crown.

"Dr. Richmond usually takes a thin, perforated disk of gutta-percha, pushes the post through it, warms the crown, presses it into place, and when cooled removes the crown, and with a sharp knife trims away the gutta-percha close to the crown-neck. He then warms the crown, puts a very little oxyphosphate cement on the post, and presses the crown home.

"The obvious advantages of the device are—the readiness with which the slopes of the root-end may be shaped with a file; the facility with which these slopes may be given any angle to set the crown out or in at

Fig. 807.

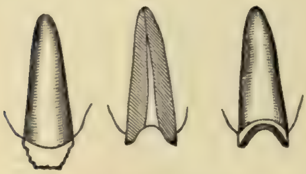


Fig. 808.

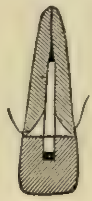
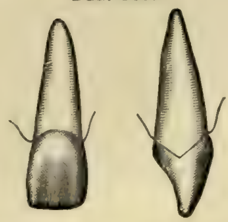


Fig. 809.



the base or at the cutting edge, or to give it a twist on its axis; the certainty that, once adjusted, the final setting will exactly reproduce the adjustment; the assurance that in use the crown will not be turned on its axis—a most common cause of the loosening of artificial crowns; the firmness of its resistance to outward thrust in the act of biting. This fact is made apparent by Fig. 806, wherein it will be seen that in an outward movement the crown *B* must rock upon *A* as a pivot, while the dotted line *D* shows how the crown-slope is resisted by the root-slope, which extends so far toward the incisive edge that a much firmer support is given to the crown than if the resistance should be, as it usually is, on the line of the gingival margin *C*.

"The cases for which the new crown seems specially adapted are such as have some considerable portion of the natural crown remaining, and for these it would seem that no better artificial substitute has yet been made accessible to the profession.

"For roots that have become wasted below the gum-surface the new crown is not suitable, except in such cases as are decayed under the labial or palatal gum-margin only, but have yet projecting the approximal portions of the crown. (See Fig. 807.)

"The sectional view (Fig. 808) and the perspective plan views (Fig. 809) illustrate the manner of mounting these crowns on this class of roots. The finished crown appears as in Fig. 809.

"The successive steps of the process must in every instance be taken with prudence, skill, and judgment, while carefully considering every circumstance and detail as progress is being made in the operation. For example, in the fitting of the crown to the root it will require nice observation and discrimination to determine whether the crown is resting on one or both of the root-slopes or on the post-slopes in the reamed canal. Emphasis on the necessity of due attention to all the considerations connected with the adaptations and manipulations of these crowns appears all the more requisite when one observes the avidity with which thoughtless enthusiasts take hold upon a new device."

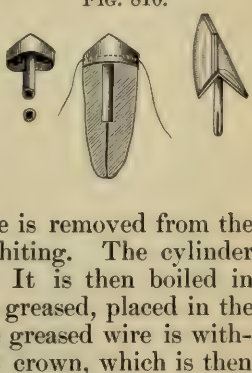
Removable Crowns.

Types of these crowns were formerly made to admit of easy removal for treatment of diseased alveoli. They are constructed as the post and plate crown, but instead of being fastened in the pulp-canal, their posts

are slipped into a close-fitting tube which has been fixed in the root at a previous operation. Another purpose served by them was to prevent turning of the post in the canal and thus altering the position of the crown, the tube being made square or triangular. The original method consisted in first forming the tube. A piece of triangular wire of No. 16 gauge was covered by thin platinum of about No. 33 or No. 34, the platinum burnished closely to the wire. The wire withdrawn, the line of junction on the plate was touched by borax and soldered with pure gold. The canal of the root was reamed for two-thirds its length and the length measured on the tube. The wire was thrust through the tube and projected for about one-eighth of an inch at its end, and the tube sawn off to the length marked, cutting through wire and tube. In the apex of the root a strand of gilling twine or a twist of oiled cotton was placed. The tube and wire were then inserted in the root, the tube flush with the prepared root-face, the wire projecting. Amalgam was packed about the tube by means of slender instruments until the filling was flush with the root surface; some operators packed gold instead of amalgam about the tube. The wire was withdrawn, the thread caught on the end of a broach, and it was removed. The post and plate crown was then made, using the triangular wire for the post. Round and square tubes and wires were also employed. This device forms the principle of construction of one of the present abutment crowns of a removable bridge piece.

A removable crown, devised by Dr. C. M. Richmond, is employed as an abutment crown for removable bridges. The root is trimmed and the pulp-canal enlarged for about half its depth to receive a post slightly larger than No. 16 gauge (Fig. 810). A ferrule is made to fit the prepared root, and an opening made through its top, uncovering the canal entrance. A thin piece of iridio-platinum plate is bent into a cylinder to enclose tightly a No. 16 wire. This cylinder is soldered. The wire is placed in the cylinder, and the pieces are thrust through the opening in the cap into the canal. Ferrule and cylinder are united by means of adhesive wax, withdrawn, and invested. The wire is removed from the cylinder, the opening of which is filled with whiting. The cylinder is attached to the ferrule by means of solder. It is then boiled in pickle, smoothed, and polished. The wire post is greased, placed in the tube, and the piece is cemented to the root. The greased wire is withdrawn, and serves as the post of a plate and post crown, which is then constructed. To ensure tightness of the post in its socket the end of the wire is to be slotted for about one-eighth of an inch or more by means of a very fine saw-blade. The leaflets thus made are slightly separated, so that some pressure is necessary to force the post into its socket.

FIG. 810.



The Genese Crown.—This crown contains a small platinum cup burnt in the porcelain, into which the post which enters the root-canal is soldered. The crown is then to be adjusted to the root and fastened to it by oxyphosphate cement in the usual way. These crowns, like those of Bonwill and Foster, may be replaced, should one of them break, without removing the post.

Facings for Bridge-work.—Dr. D. Genese has introduced a thin porcelain facing for bridge-work, the inner surface of which is lined with thin platinum imbedded in the porcelain by means of a fold in the thin metal. The platinum serves the purpose of a backing, and the teeth may readily be soldered to the framework of the bridge without other preparation than the usual fitting.

Crowns with Removable Pins.—This form of crown has been introduced for the purpose of having a readily detachable pin which is capable of easy and permanent fastening. It consists, as shown by Fig. 811, of a porcelain crown having a threaded socket, I, to which is fitted a corresponding threaded silver pin, II. The advantages claimed for it are that the pin may be detached, so that the fitting of the crown to the root may be accomplished with greater convenience, and that the pin may be bent in adjusting it to the root while detached from the crown, thus avoiding danger of fracturing the porcelain.

Fig. 811.

Fig. 812.

Fig. 813.

The porcelain facing is to be adapted to the root face by grinding. A layer of wax is then placed over the root and the crown pressed into it, indicating the exact site to be occupied by the threaded screw. The root is then reamed at the point indicated until it readily admits the post and is of sufficient depth to serve to retain the post securely, the crown screwed on the thread, and the post is fastened in the canal as for any post crown.

The Hollingsworth System of Crown- and Bridge-work.—A system which affords greater range of ready application than any of its predecessors is that known as the "Hollingsworth." Its claims and description are thus given by its inventor:

"Accuracy of method, simplicity of procedure, and beauty of result are essential to any system of making crowns or building bridges which shall bring the successful prosecution of this desirable branch of practice within the reach of the great majority of dentists.

"The Hollingsworth system has been before the profession more than two years, and it has made many men crown- and bridge-workers who before its advent sent their patients to specialists. Any dentist of average attainments can work it successfully.

"This system supplies, in the first place, a variety of forms for the various teeth great enough to cover almost any case, and for the rare cases which cannot be suited direct it affords a ready means of making the exact form required. There are in the set two hundred and four forms of cusps and thirty-six of facings for bicuspids and molars, and forty forms for incisors and cuspids. These last give both the labial and lingual faces. All the forms are exact facsimiles from nature, selected

Fig. 814.


A
B
C
D
HOLLINGSWORTH'S
Annealed Copper Strips
FOR TAKING MEASUREMENTS OF ROOTS.
THE S. S. WHITE DENTAL MFG. CO.
E
F
F

with great care to cover the widest range possible. They are made of metal, and are used as patterns from which to make dies or moulds, as may be required, for the swaging of gold cusps or crowns. There is therefore no wear upon them, and they retain their shapes and sizes unaltered.

"The outfit for working these forms consists of a moulding plate, three rubber rings, a sheet of asbestos 10 by 7 inches, a carbon stick for use in casting, and a box of Hollingsworth's annealed copper strips for measuring roots.

"This system permits cusps to be made either hollow or solid. Scrap gold can be used for casting solid cusps, and porcelain facings can be quickly inserted in crowns without investing; but perhaps its most important advantage is the exactness with which the fit and articulation of bridges are obtained and maintained."

Directions to Make a Gold-crown Bicuspid or Molar.—Make a band to fit the root in the ordinary way. Place the band in the mouth (see Fig. 815), and cut off on a line where the adjoining teeth begin to turn to form the cusp (see *c*, Fig. 815). Place a small piece of wax inside the band to assist in holding the cusp-button, which should be selected to fit the circumference of the band, to articulate properly, and

FIG. 815.

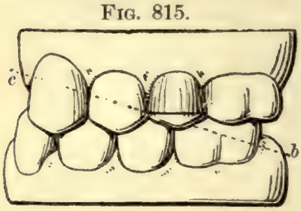


FIG. 816.

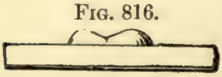


FIG. 817.

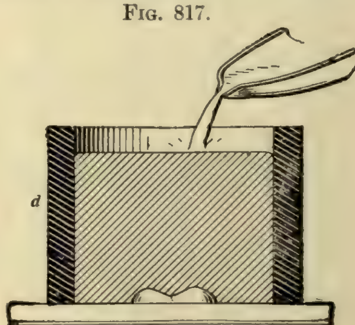


FIG. 818.

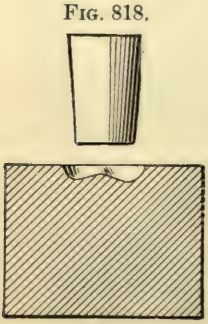


FIG. 819.

FIG. 820.

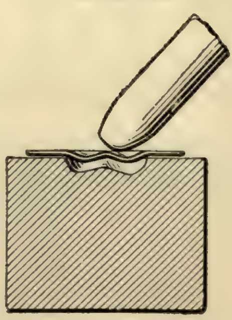


FIG. 821.

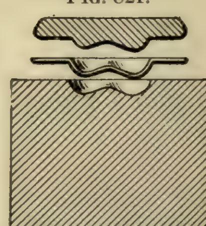
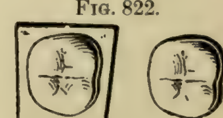


FIG. 822.



to correspond in shape with the other teeth (see *b*, Fig. 815). Remove the button and place it on the moulding-plate with the grinding surface

up (see Fig. 816). Place the small rubber ring *d* around it, with the button as near the centre as possible, and pour in a sufficient quantity of Melotte's metal to nearly fill the ring (Fig. 817). Start to pour the metal directly on top of the cusp, otherwise the flow of metal may force the cusp to one side and make an imperfect die. As soon as the metal sets, chill the surface by dipping in water for a moment, and then remove the rubber ring. When the heat begins to return to the surface, a quick rap of the die on the bench will cause the cusp-button to drop out and leave the mould ready to form the gold cusp. Now take a piece of lead (Figs. 818 and 819) and with a hammer drive into the Melotte-metal die (Fig. 820) to form the counter-die.

Anneal the gold plate, and start the swaging process by coaxing the plate into the die by hand-pressure (Fig. 820), using a piece of wood, which makes a depression for the lead counter-die to rest in. Then place the counter-die on the gold plate (Fig. 821) and drive to a partial fit. Remove the partially formed cusp, pickle it to remove traces of lead, and again anneal it. Place the counter-die on the die without the gold plate, and drive it in with a smart blow; this will resharpen all the lines of the counter-die. Next replace the partly formed gold cusp in the die, and again drive the counter-die into it for a perfect fit. Again pickle the cusp, and proceed to cut the surplus metal from it with shears (Fig. 822), filling up the edges when necessary, and rub down the under surface on a smooth file until its fits the band made for it (Fig. 815). Wire the cusp and crown together (Fig. 823), place flux and solder in the cap, and hold over a lamp until soldered. Then finish in the usual way.

Fig. 823.

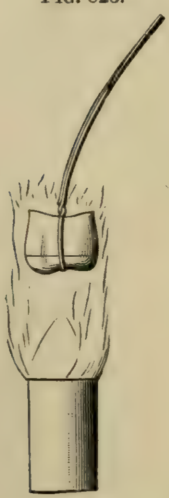
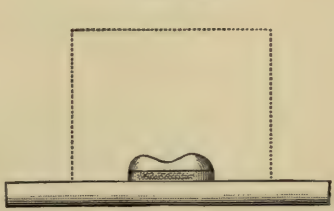


Fig. 824.

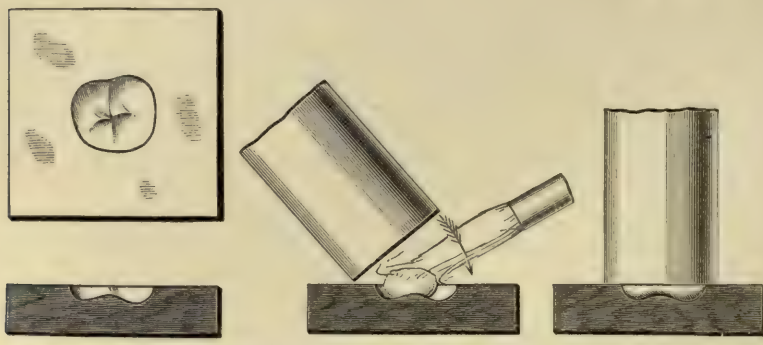
Fig. 825.



Note.—If the forms of cusp-buttons do not afford one which articulates perfectly, the difficulty is easily remedied by taking the button which most nearly answers, and building up the cusps with Melotte's moldine (Fig. 824). If necessary to make an absolutely perfect articulation, and the forms as supplied do not permit of it, select a cusp that will otherwise suit the case, set it on the band on the crown, cover the face of the cusp with moldine, coating the surface with collodion to prevent the saliva from crumbling it, and direct the patient to bite upon it, or, if a perfect plaster model has been made, articulate the opposing teeth with the cusp placed on the band, omitting the coating with collodion. Remove the cusp with the moldine, trim off the surplus, and proceed to cast as shown in Fig. 817. If a band is accidentally cut too short, it can

still be utilized. Place moldine upon the moulding-plate, put the cusp-button upon it, press down and adjust to make up the deficiency of the

Fig. 826. Fig. 827.



band, cutting away the surplus moldine. This will of course throw the soldering line a little farther up on the crown (Fig. 825).

To Make Solid Gold Cusps.—Scrap gold can be utilized for making a solid gold cusp by casting in asbestos by the following method:

After selecting the desired cusp-button, instead of making a mould in Melotte's metal, as before described, take a piece of asbestos board about one inch square and one-fourth inch thick, moisten it, and with a hammer drive the cusp-button into it flush with the surface of the button. (See Fig. 826.) Remove the button, and dry the asbestos in a flame (Fig. 826). When perfectly dry, place a sufficient quantity of gold scraps in the die made in the asbestos, and direct the blowpipe flame upon it until melted, inclining the carbon stick, as shown, against the die for the double purpose of confining the heat and warming up the carbon stick. When the gold is fused into a button, press it into the die with the carbon stick (Fig. 827). Avoid the use of flux when working with asbestos.

To build up a cusp to make a perfect articulation in this manner, sealing-wax must be used instead of moldine, as in the method of swaging the cusp. Warm the button before applying the wax, and with a warm instrument shape the cusp as desired.

To Make Gold Crowns (Centrals, Laterals, and Cuspids).—Select from

Fig. 828.

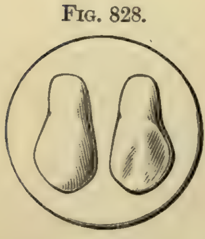


Fig. 829.

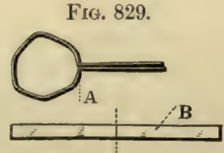
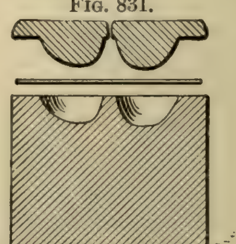


Fig. 830.

Fig. 831.



the forty different forms in the set that which is most suitable to the case in hand (Fig. 828). (The forms are in pairs, showing labial and lingual

surfaces.) Take the measurement of the root to be crowned with one of the annealed copper strips, binding the strip around the tooth with pliers and pinching the joint firmly together. Trim off the surplus ends, and cut the measure (Fig. 829, *A*) through the centre (Fig. 829, *B*), then bend the respective halves over the lingual and labial forms selected, at the necks, with the cut ends of the strips resting on the flat of the plate (Fig. 830). If the measure is larger than the form selected, build the latter up with moldine until the space between the form and strip is filled (Fig. 830, *B*). Avoid getting moldine on the approximal surface. Remove the strips, dry out the moldine by passing through a flame a few times, then place the form on the moulding plate with a rubber ring around it. Pour Melotte's metal into the ring as in forming the molar or bicuspid cusp, which makes a die of the two sections, lingual and labial. Make a lead counter-die and proceed as directed in the making of a molar cusp, swaging the sections separately (Fig. 831). Trim off the surplus plate (Fig. 832), and square the opposing edges of the two sections by rubbing them over a dead smooth file. Bind the two sections together with wire with sufficient solder and flux inside (Fig. 833 and Fig. 834), and proceed as in soldering an ordinary band.

FIG. 832.

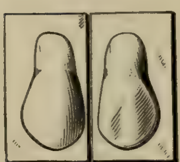


FIG. 834.

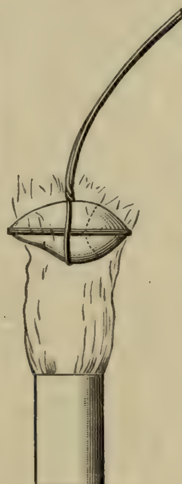


FIG. 833.

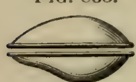


FIG. 835.

With a small mechanical saw cut off the upper portion where the tooth begins to slope back (about the dotted lines in Fig. 834). This leaves the crown as shown in Fig. 835, approximal and labial views. Drive on the root. If too small, place on the horn of an anvil and enlarge by hammering; if too large, band the root in the same manner as for a Richmond crown, grinding the tooth to fit.

To Insert a Porcelain Facing.—Make the gold crown as described. Select a porcelain facing suitable for the case (Fig. 836). Place the crown on the root in the mouth, and with an excavator mark on the face where the porcelain is to appear. Remove the crown and saw out, so that the facing will fit loosely. With a knife bevel the inner edge or seat for the facing (Fig. 837). Grind the facing to fit (Fig. 838). Back up the facing with No. 34 or 36 gauge pure gold, punching holes in the backing for pins, annealing as required to readily conform it to the tooth (Fig. 839 and Fig. 840). With a sharp knife cut a barb on each side of the pins in the facing, and press the barbs against the backing (Fig. 841), to keep the backing in place. Burnish down the edges well, being careful not to let the backing overlap the facing.

Place the facing in the space prepared for it in the crown (Fig. 842),

and bind the two together (not too tight) with wire, wrapping the wire directly over the facing with asbestos to prevent discoloration of the porcelain. Flux and solder by holding over a lamp as in the case of a band (Fig. 843). Then finish in the usual way.

If it is desired to use a platinum pin for anchorage—as, for instance, a Logan pin—bend the pins in the facing sufficiently to clamp the an-

Fig. 836.

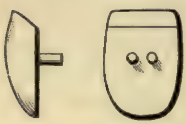


Fig. 837.

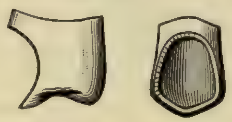


Fig. 838.

Fig. 843.

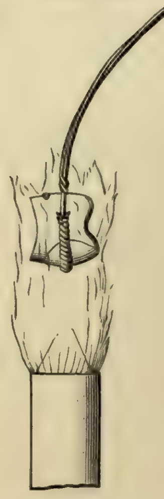


Fig. 839.

Fig. 840.

Fig. 841.

Fig. 842.

Fig. 844.

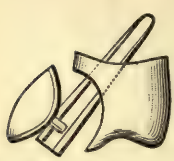
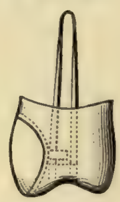


Fig. 845.



chorage pin, and insert the pin through the gold crown (Fig. 844), finishing as before described. Fig. 845 shows a finished crown so made.

Annealed Copper Strips.—These strips will be found more desirable and practical than the ordinary binding-wire for taking measurements of roots, especially of badly-decayed teeth. To use them, the strip is passed around the tooth, and the joint pinched firmly with a pair of pliers. Where the decay runs under the gum, tack the ends of the strip together with soft solder, and with an excavator carry it well up under the gum.

By the Hollingsworth system the following operations are performed with great ease and accuracy: Gold crowns, bicuspids and molars; gold crowns, incisors and cuspids; solid gold cusps; grinding surface of a bridge in one continuous piece; porcelain facings; facings for making an all-gold bridge.

The large cut (Fig. 814) shows the cusp and crown forms in a folding case as they are put up for sale. In the upper half of the case there are two hundred and forty cusp forms and facings for bicuspids and molars; in the lower half there are forty forms for incisor and cuspid crowns. From this great number patterns can readily be selected that will perfectly articulate with the opposing teeth.

A (Fig. 814) is the polished plate upon which the dies are made.

B is a carbon rod for pressing the melted metal into the asbestos mould.

C is part of the asbestos sheet, 7 by 10 inches, in which dies are formed for casting solid gold cusps.

D is a box of annealed copper strips for taking the measure of the root to be crowned.

E and *F* are rubber rings in which the die is made from Melotte's metal.

Numerous other systems have been devised to facilitate the operations of crown- and bridge-work, but all of them have either such limitations as to accuracy or insufficiency of application that the description of them would needlessly overload these pages.

Repairing of Crowns.

The chief accident befalling artificial crowns is fracture of their porcelain facings. It is unusual for those composed wholly of metal to require repair; occasionally, if made of too thin metal, these crowns may wear through and expose the cement.

It may be found necessary to remove a barrel crown to gain access to the root-canals in order to sterilize these canals should sterilization have been incomplete before the crown was set or in the event of a pulp dying and decomposing subsequent to the setting of the crown. When the crown has been properly fitted and attached, it will be found, as a rule, that it is necessary to split the barrel to enable the operator to detach the crown. A sharp hatchet excavator is drawn from the cervical edge to the masticating surface of the crown, making a groove of increasing depth until the division of the barrel is complete, when the edges of the flaps are bent away from one another; a fine explorer is passed beneath the cap as far as possible and the cement dislodged piecemeal. A broad-edged excavator is then placed above the edge of the collar and traction exerted at all points until the barrel loosens.

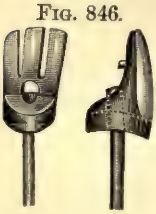
The crown is now boiled in strong nitric acid to dissolve the remnants of cement attached to it. It is then readjusted to the tooth, the cut edges brought into apposition, and removed from the root. Should it be necessary to repair thin areas or spaces where the crown is worn through, a piece of platinum No. 36 is pressed against the break from the inside; an ample amount of flux is flowed over the surface, and sufficient solder (16-carat) placed in the cap and fused over a Bunsen flame.

To repair the line of division, a strip of thin platinum about one-sixteenth of an inch wide is covered with fluxed solder filings and pressed against the break in the inside of the barrel. The crown is now invested, fully exposing the line to be soldered, which is covered by borax and a small piece of solder laid at each end of the line. The crown is now heated and soldered.

To remove collar crowns having their porcelain facings broken away, it is advisable to first groove the backing from its upper edge, making two slots large enough to permit the slipping of the pins of the new facing into them. A fissure bur is passed through the base of the stay and top of the ferrule, severing the attachment of the post; an old excavator is passed beneath the cap, its angle resting upon the face of the root, and the endeavor made to pry off the ferrule, for, if possible, the ferrule should be removed without splitting. The stay may be

grasped in the beaks of a pair of forceps and gradually worked loose and removed. If it becomes necessary to split the collar, it is advisable to make a new crown. If the band and stay are removed without splitting the collar, a spear-pointed drill is passed through the cap at the base of the stay; this perforation serves as a passage for the new post. A fine bur is passed around the post, removing the cement for about half the depth of the post. As a rule, more or less incidental enlargement of the canal is unavoidable. The end of the post is caught between the beaks of a pair of forceps and gradually worked loose, when it is removed. The remainder of the cement is now drilled from the canal. The stay is filed away at its anterior face sufficiently to allow for a new stay of No. 33 plate. The collar is adjusted to the root and a post passed through the perforation made in the cap into the root (Fig. 846, *a*). An impression is taken in which ferrule and post are removed, and a cast made of investing material. A suitable tooth is selected and a stay of No. 33 pure gold or platinum plate burnished to its back; the pins of the crown remain unbent, and are passed into the cuts made in the original stay, enlarging the latter should it be necessary. The tooth is accurately ground to position (Fig. 846, *b*), and when fitted the surfaces of the stays are covered with borax, the tooth set in position, and investing material placed over it, leaving the palatal surface of the crown exposed. A piece of solder (14-carat) is placed over each pin, two small pieces at the upper line of junction of the stays, and a large piece over the exposed end of the post. The case is thoroughly heated from the outside; in fact, it is better to direct the heat against the investment covering the tooth until the solder at the edges flows and unites the new and old stay. A fine flame directed against the solder over pins and post flows it into the depressions about them.

FIG. 846.



a *b*

Substantially the same procedures are followed in removing the post and plate crown when attached by means of zinc phosphate. The great difficulty in these cases is in removing the posts: it is necessary to remove the cement for some depth before it is possible to loosen them: the difficulty is increased with posts having the Logan form. An opening is made through the plate for the passage of the new post, the surface of the stay ground down for the reception of the new stay, and the slots are cut in the backing as described. Should a straight-pin tooth be employed, holes are drilled for the reception of the pins; these openings are elongated toward the base of the stay, so as to accommodate the pins of the tooth while it is being fitted. A new post is fitted and placed in position, the impression taken, and the new tooth mounted as in the operation previously described.

In removing the metallic basis of crowns which have been attached by means of gutta-percha the retaining medium is to be softened sufficiently to permit the withdrawal without mutilation. After gutta-percha has been worn for a long period it becomes difficult to soften. Probably the most effective means of attaining this end is to heat the jaws of a pair of heavy pliers; then, after protecting the lips and gum with napkins, grasp the stay between the jaws of the pliers, and after some time exert traction and draw the post from the root. The crown

base is heated and the remnants of gutta-percha burned off. The stay is thinned as in the former case, and cuts or holes made for the reception of the pins of the new facing, which is backed, fitted, and attached as described.

Retaining Media.

The two materials commonly used as retentive media for artificial crowns are gutta-percha and the phosphate of zinc.

Each of these substances possesses properties which govern their employment. Oxyphosphate is adhesive, extremely hard, therefore difficult of removal, and is more or less soluble in the fluids of the mouth. The greater the amount of acid present in the saliva, the greater the solubility of the cement. It disintegrates most quickly at the cervical margin, where acid formations are in greatest amount, and is somewhat porous. Protected from contact with the oral fluids, it lasts indefinitely.

Gutta-percha is almost unchangeable in the mouth, is plastic, is softer than zinc phosphate, and loses substance by attrition. It may be resoftened by heat, but softening becomes more difficult with age.

Therefore, zinc phosphate is selected for the retentive medium when it is protected from the fluids of the mouth, where such space exists as demands more rigidity than could be furnished by a mass of gutta-percha, and where adhesiveness is a desideratum, where support is to be furnished for a metal surface susceptible to change of shape, as, for instance, in a thin gold crown, where gutta-percha, if used, would by its elasticity permit change of shape in the band.

Gutta-percha is to be employed where the fluids of the mouth have access, where such a thin layer of retentive medium is required that its pliability does not affect its fixation, or where it may be desirable to furnish means for removal of a crown should this ever become desirable.

Thus in all crowns supported by bands or barrels which extend beneath the edge of the gum zinc phosphate is the proper retaining medium.

Also in cases where a large space exists between crown and root; that is, an interior space not marginal, for marginal adaptation in all crowns must be perfect.

In those crowns which are placed upon posts which have been fixed in roots to serve as supports to porcelain crowns or faces the retentive medium becomes practically part of the crown.

Setting Crowns with Zinc Phosphate.

The zinc phosphate employed in the setting of crowns should possess the characteristics which would recommend the specimens to be used as filling material. It should, however, flow freely, and, as the difficulty of maintaining dryness is increased, it should set promptly and yet with sufficient deliberation to permit the accurate adaptation of the crowns. The operator should by actual test determine precisely the peculiarities of the particular cement he is to employ. Specimens of zinc phosphate differ so markedly in their behavior that it is always wise to make preliminary tests of each package.

In setting post crowns with zinc phosphate the following will be found a satisfactory method: The root is protected from the access of

moisture, cleansed with strong pyrozone, and dried by means of the hot blast. A couple of drops of the cement fluid are placed on a mixing slab, and beside it an excess of powder; the latter is to be gradually combined with the fluid, adding little by little and mixing well with a spatula until the paste is thick enough to be rolled into a pellet which changes shape through its own weight. A pellet, rolled long, is passed into the root; the post and under surface of the crown are covered with cement and pressed quickly into the root; the surplus—and there should always be a surplus—is squeezed from about the edges of the crown. The napkin is held in position and dryness maintained until the cement on the slab is hard and resists the edge of a knife-blade.

The advantages of gutta-percha covering the root face and the rigid phosphate filling the pulp-canal may be both had by the following method: A thin disk of gutta-percha is perforated and passed over the post and pressed against the base of the crown. It is then set upon a gutta-percha heater. The root is thoroughly dried, and the zinc phosphate placed in the canal. The crown is firmly pressed into position, the surplus cement emerging from beneath the edge of the crown and the gutta-percha being reduced to a thin film.

Another method of combining the two media, applicable to roots which have suffered much loss of tooth-substance about the periphery of the canal, is as follows: A stick or wire the size of the crown-post is smoothed and covered with vaseline or any oil to prevent the adhesion of the cement to its surface. The root is filled with cement, and the greased post thrust into it, and moved about slightly to press the cement away from it to permit its easy withdrawal. When the cement has set all portions which interfere with the proper placement of the crown are removed, and the crown mounted with gutta-percha as described.

In setting barrel crowns the root is dried and protected by napkins; the cement is mixed thinner than for setting post crowns; the irregular parts and undercuts of the root are filled with the cement; and a portion of the plate is flowed into the deepest portions of the crown, which is then promptly set in position over the root and firmly pressed into position. A piece of tin-foil (No. 20) is doubled and set over the surface of the crown; the napkin is removed and the patient is directed to close the jaws, and hold them firmly closed until it is seen by testing the cement on the slab that it has hardened. It is the usual practice to perforate barrel crowns in the deepest point of the masticating surface to permit the escape of air and the surplus cement. The opening thus made is to be filled with gold-foil when the cement is fully hardened.

In setting the post and collar crowns a cone of soft cement is placed in the root-canal; the concavity of the ferrule is filled with cement, and the crown is pressed into position. After the cement has set a fine instrument is to be passed around the margin of the collar or barrel to remove any particles of surplus cement. Should any of these fragments remain, they may form a source of serious irritation to the soft tissues.

Setting of Crowns with Gutta-percha.

The office of the retaining medium is twofold—first, to furnish a structure which shall serve as a mechanical support throughout its

length and surface, to restore any imperfections of union between the root and the crown, so that the two factors are bound together in a fixed mechanical unit. Secondly, the medium is to act as a protector to the surfaces of the root against the encroachment of the active causes of dental caries.

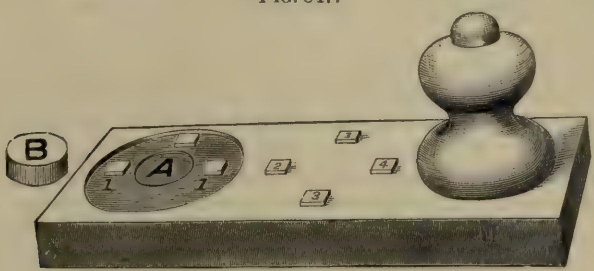
It will be seen, therefore, that the retaining medium, whether it be gutta-percha or zinc phosphate, is to be so manipulated that it shall perfectly fill the minute interstices of the parts it unites.

When gutta-percha is to be employed, it is necessary that the several parts shall be at a temperature which will permit the ready, deliberate, and accurate adjustment of the crown and gutta-percha to the root.

A satisfactory method of manipulation is as follows: A napkin is adjusted so that the root is protected from moisture; the canal is wiped out with caustic pyrozone. The post is now barbed, so that the gutta-percha will be mechanically held to it: a sharp enamel-chisel or knife-blade is used to nick the post.

The crown is laid upon a gutta-percha heater (Dr. How's steatite slab is useful for this purpose), a piece of tough gutta-percha is laid beside the crown, and when soft is pressed out between the fingers into a sheet,

FIG. 847.



How's heater.

which is wrapped around the heated post. The root-canal is wiped out with oil of cloves, so that the gutta-percha will not adhere to it, and the heated crown and softened gutta-percha are pressed into position. If an excess of gutta-percha has been applied, the surplus will be squeezed from beneath the outlines of the crown. This excess is to be trimmed away by means of sharp scissors. If there has not been sufficient gutta-percha attached to the post, more is to be added to that on the post and the crown reapplied, and then the excess trimmed off. The crown is returned to the heater, which is again held over the flame until the fusible metal melts. A fresh napkin is placed in position; the root is wiped out with chloroform and dried by means of a hot blast. A small sheet of softened gutta-percha is added about the post, and when the crown and gutta-percha are thoroughly heated the crown is seized between the fingers, protected by a napkin, and pressed into position. A heated crown adjuster (see Fig.—) is now applied to the crown, and it is forced into position; the excess of gutta-percha is squeezed out at the margins of the crown.

CHAPTER XIX.

AN ASSEMBLAGE OF UNITED CROWNS (BRIDGE-WORK).

By H. H. Burchard, M. D., D. D. S.

A dental bridge is essentially a continuous masticating surface anchored to supporting abutments at two or more points of its length, the fixation and retention of the device depending upon anchorage on or in the natural teeth; any support derived through contact of the appliance with the natural gum is purely secondary. The method and variety of support are the direct reverse of those of an artificial denture mounted upon a plate, for here the primary support is by the natural gum, and any further support derived through attachment to the natural teeth is merely adjunctive.

The appliances in contemporary use which are included under the head of "dental bridges" comprise a multitude of devices, the construction and support of which depend upon a few principles. The many different forms are modifications of a limited number of types, the differences between many of apparently diverse types being merely technical and not those of mechanical principles.

The natural teeth or roots supporting the bridge are called its "abutments," the crowns placed over them or the bars anchored in them, the "abutment pieces." The intervening portions of the fixture are known as "the body of the bridge," and the several pieces of which it is composed, "the dummies."

History.—Devices which might be classed as dental bridges are probably as old as the earliest attempts at dental prosthesis. The placing of a band of metal about one natural tooth is the simplest means for supporting an additional tooth, and probably the first attempted.

Among the archæological remains of the Etruscan life are found devices which bear a family resemblance to bridge-work.

The present varieties included in the generic name of dental bridges are the evolution of processes and types suggested and made early in this century. As an example of an early device bearing a close resemblance to a contemporary appliance, Dr. W. F. Litch[1] gives a cut from the work of F. Maury (1828), showing six anterior teeth anchored in the roots of the cuspids by means of two posts placed in the enlarged pulp-canals.

In April, 1855, Dr. Wm. H. Dwinelle[2] described the progenitor of the modern pin and plate bridge, together with the prototype of another form of bridge in present use: "After the root is filled with gold . . . .

[1] *American System of Dentistry*, vol. ii., Fig. 758.
[2] *American Journal of Dental Science.*

and properly finished, an impression of its surface is taken in wax, from which castings are made, and from these plates are swaged. These are adjusted to the tooth and a golden pivot soldered to the upper surface. A plate tooth is now skilfully adapted to the fixture, when it is ready for use. *In this way a plate may be carried across an intervening space unoccupied by roots, and an unbroken row of teeth mounted upon it.*"

In January, 1871, Dr. Benj. J. Bing applied for a patent for a bridge device to be anchored by wire extremities into cavities in the natural teeth.

A form of removable bridge was introduced by Dr. W. G. A. Bonwill in 1873 (Fig. 848).

The revival of bridge-work, or the modern ideas of these forms of appliance, arose with the advent of the barrel and collar crowns. This variety of crown, made and applied early in the century, appears to have had very limited employment until its elaboration by Dr. C. M. Richmond. The primary principle involved was, as stated, known and applied for many years; it is but fifteen years, however, since the general adoption of the idea.

Fig. 848.

In its simplest form a dental bridge consists of two or more crowns bearing between, and rigidly attached to, them substitutes for the crowns of the intervening natural teeth which have been lost. The primary object sought has been disuse of a plate, and such firmness and immobility as would furnish a better means in mastication than is possible with a plate denture.

Classification of Bridges.

Dental bridges may be divided into two primary classes—fixed or removable.

Fixed bridges are those which are so attached to the abutments that removal of a properly fitted and adjusted piece is not practicable without more or less mutilation of the abutment crowns (Fig. 849).

Fig. 849.

Removable bridges are those whose supporting crowns may be detached from the abutments without disturbing the integrity of the appliance.

Class 1 may be subdivided into sub-classes according to the method and means of anchorage:

Sub-class 1: Those attached to the abutments by means of collar or barrel crowns (Fig. 849).

Sub-class 2: Those in which fixation is secured by means of metallic bars anchored in the crowns or roots of teeth. (See Porcelain Bridges.)

The features of both sub-classes may be combined in one piece, a bar anchorage at one extremity and a collar or barrel crown at the

other (Fig. 850). Devices of the varieties of Dr. Litch's pin and plate bridge belong to sub-class 2; the open-cylinder partial crown terminals to sub-class 1.

The usual forms of removable bridges have abutment crowns made of cylinders, which telescope over metallic ferrules which have been permanently attached to the abutments. This form of bridge was devised to facilitate removal when repair of the piece became necessary; to permit of occasional removal, so that the bridge might be perfectly cleansed; to furnish a method of attachment when the abutment teeth were in such malposition that a fixed bridge could not be attached without undue mutilation of natural crowns.

FIG. 850.

The introduction of the removable bridges has negatived several of the objections urged against the practice of this work. First, the want of perfect cleanliness, for removable bridges may be detached when necessary and receive a perfect cleansing. In case of repair being necessary the piece may be removed without mutilation of the abutment crowns. It furnishes a means for bridging spaces enclosed by overhanging teeth. These bridges possess so many advantages over the fixed variety that it is probable they will largely supersede the latter.

A type of device somewhat resembling a bridge has been constructed and described, which combines some of the features of both bridge and plate. Extending from the terminal abutment pieces of a bridge are arms or wings resting upon the gum and supporting one or more artificial teeth on each of them. The mechanical principle involved in this device is faulty. The plate pieces to furnish any material support must be of such size as to render the appliance highly objectionable hygienically; and if too small to serve as effective auxiliary supports, the abutments are overstrained (Fig. 829).

In judging of the merits and demerits of this phase of prosthesis, it would be manifestly improper to accept all the claims of the enthusiastic advocates or to be governed by the opinions of its pronounced opponents.

The advantages claimed for bridge-work are the removal of many of the deficiencies associated with plate dentures. First, the bridge is immovable; second, there is no interference with articulation; third, teeth may be replaced without the necessity of wearing a cumbrous plate. The several advantages enumerated by advocates may be all summed up under these three headings.

The objections urged against bridge-work in the past have been in great measure removed; others remain. It does not restore lost gum contour, except with those devices known as plate bridges. It is uncleanly; the spaces existing between portions of the bridge surface and the natural gum are frequently inaccessible to the tooth-brush and contain decomposing food débris. Teeth are necessarily mutilated to serve as correct abutments. It is frequently necessary to destroy vital pulps. The abutments may be subjected to a greater mechanical stress than they can safely bear. Difficulty of repair has been a serious objection.

The intrinsic merit of properly constructed bridge-work is undoubted. Many of the objections stated above do not attach to properly designed and constructed pieces; they are based upon such practice of bridge-work as is now regarded as unjustifiable.

It is to be recognized that neither bridge- nor plate-work is of universal application; each case presents indications which should determine what form of prosthesis is applicable.

The work has unquestionably a great field of useful application: cases there are in which this type of fixture is a well-defined need, and others in which it is clearly contraindicated.

The first inquiry of the operator should be, Is a bridge demanded by the conditions present? that is, Does a bridge device possess for the case in hand sufficient advantage over a plate denture to render its use an imperative indication? Upon this point turns the entire subject of the wisdom or unwisdom of bridge-work.

The student is assured that in the practice of this special field he will find application for an exhaustive knowledge of dental pathology, therapeutics and mechanics, combined with rare manipulative ability; in point of fact, the work should not be done unless the operator possess this degree of knowledge and skill.

The requisites for its correct practice mark the mechanical and physiological aspects of bridge-work.

Mechanical Aspect.—Under the mechanical aspect are included all considerations of resistances to stress and the effect of stress as expressed in the mobility of the bridge, of any part of it, or of its abutments. The same considerations governing the mechanical resistance of roots or teeth when serving as bases for artificial crowns, apply with increased emphasis when they are to be the abutments of a bridge piece.

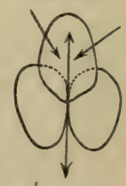
The student is presumably familiar with the anatomy and the anatomical variations of the teeth as to their forms, structure, and positions.

Any stress greatly in excess of the amount normally borne is a menace to the integrity of a tooth's retention. The increased mechanical stress reacts physiologically, and by a pathological process the tooth is loosened and lost.

The vertical is the only direction of force which does not tend to mechanically dislodge a tooth, and it is one to which teeth are rarely subjected alone. As a rule, teeth protest against stress received in any direction other than that due to their anatomical forms and positions. Incisors are by these factors designed to meet and resist stress—to move in one direction, either outward or inward. The broadest aspect of their root is anterior, offering at this part the greatest resistive surface.

The cuspids receive the force in two directions, each at an angle with the axis of the tooth: the resultant of the forces (the direction of the movement of the tooth) is between the two forces. According as the greater impact is anterior or posterior will be the movement (Fig. 851).

Fig. 851.



The bicuspids normally receive three main lines of force—an outward, an inward, and a vertical: the outward and inward forms are the resultants each of two forces acting upon the cusps at an angle with the axis of the tooth.

The muscular force being equal, the longer the cusps the greater will be the lateral stress; also the broader the cusps (the farther their external walls are removed from the axes of the teeth) the greater stress there will be in all three directions.

The molars also receive force in three main directions, but the lateral

forces are the resultants of several lines of force according to the sizes and positions of the cusps.

The resistances to these stresses are through the forms, number, sizes, and structure of the roots, and also of their supporting structures.

Dr. Bonwill has demonstrated a constant relationship between the lengths of the cusps and the amount of over-bite, and as a consequent the extent of the contact of the cusps in mastication. The greater the over-bite the greater surface of contact there must be, and, other things being equal, the greater mechanical stress. This is an important consideration, and one to be constantly borne in mind in the making and adjusting of crowns and bridges.

No absolute, or perhaps even proximate, rules can be formulated as to the amount of strain any single tooth will bear: attempts at the formulation are delusive.

Given two central incisors, the amount of resistance either will afford depends, first, upon the anatomical form and support of each, and their relative positions to their antagonists, and is governed largely by the physiological condition of each. Alter the relations in any particular, and the resistance is correspondingly modified.

By uniting or splinting together several teeth, as in a bridge piece, the movement of each tooth is modified or restrained, and by such fixation two natural teeth are frequently found to successfully withstand more force than the sum of their individual resistances. As an illustration observe a common condition in which a bridge is applied—an inferior second bicuspid and a third molar serving as abutment teeth. If these teeth be healthy and have firm attachment, fixing to them a rigid bridge piece prevents the tendency toward antero-posterior displacement, one of the strongest elements tending toward their loss; they are held by the bridge so that the only possible movement is lateral.

If the lateral stress be correctly governed, such teeth may safely bear crowns upon their own roots, and support intervening crowns, filling the space between them, for a longer period than were a bridge not applied.

One of the most common faults of bridge-work is, however, increasing strains without due regard to the available resistance.

Using the same bridge for illustration, the abutments are subjected to the amount of stress normally borne by four teeth. It depends upon the directions of the root-axes whether the resistance of the abutments when barred together is increased in the same degree as the stress. Their antero-posterior movement is effectually checked, but if the roots of the teeth have parallel axes, both are free to react upon lateral stress. While abutment teeth submit without protest, as a rule, to the direct vertical force of mastication, occasionally there will be found a progressive degeneration of the pericementum, which causes loosening of these teeth.

The lateral stress is the one tending to dislodge bridge fixtures, and the tendency to displacement is increased in the ratio of this stress, hence the longer the cusps, and the more accurate their occlusal union with the antagonizing teeth, the greater the stress upon the abutments.

Bridge-work should be constructed upon sound mechanical principles: to be successful as a piece of engineering work all designs are to be founded upon those principles. These fixtures are literally bridges, a continuous surface supported by rigid abutments, designed to bear safely

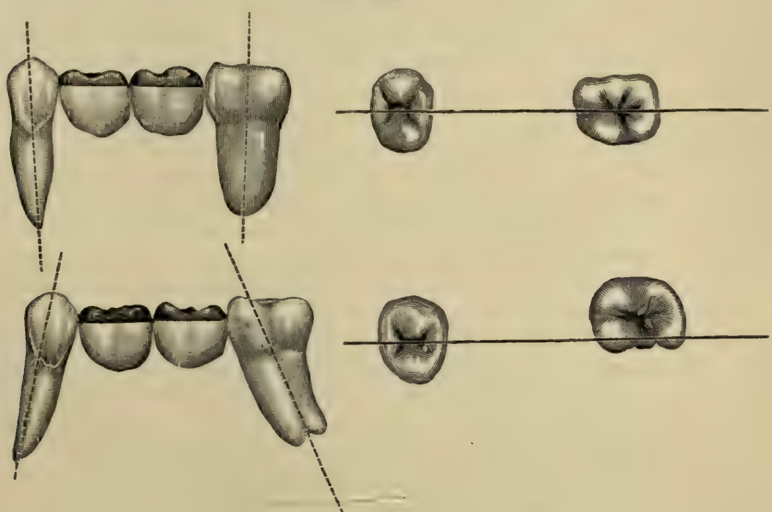
the amount of stress it is calculated the piece will be subjected to. The calculations involve the strengths of abutments, crowns, and body of the bridge. Violations of sound engineering principles are common in suggested devices: the student should examine carefully all proposed designs and select only those which are mechanically good.

An engineer recognizes that the stability and permanence of his bridge depends primarily upon the strength and position of its abutments. If these be badly built or poorly sustained, the bridge fails; so that bases are selected and prepared, abutments built, with a due regard for the weight they are to sustain, the resistance they are to afford.

With dental bridges, utilizing any but sound teeth or roots, those free from pericementitis or abscess, is equivalent to an engineer building abutments in a marsh without piles.

In designing a bridge note the directions of the least and greatest resistances, and apply the strains accordingly, and mould the articulation so that the greatest force shall be opposed to the greatest resistance and *vice versâ*. To illustrate: teeth which have their axes parallel and in the same plane (Fig. 852, *A*), all other things being equal, will withstand less stress than were the axes not parallel and in different planes (Fig. 852, *B*);

FIG. 852.



that is, when the teeth in both cases are serving as bridge abutments: with parallel axes, when one abutment moves in the direction of least resistance its fellow abutment moves with it; but if the axes be not parallel, when one abutment is subjected to stress in the line of least resistance its fellow is receiving the stress in a line of greater resistance.

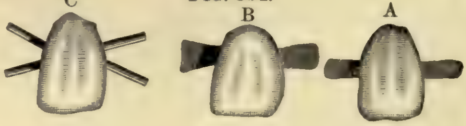
Another illustration is found in a common form of bridge—two cuspid roots supporting artificial crown substitutes of the six anterior teeth (Fig. 853). With all of the posterior teeth in position the amount of strain on the abutments is governed first by the lengths of the crowns, the leverage on the roots; next upon the amount of over-bite or the extent of incisive action occurring before the occlusion of the posterior

teeth equalizes the forces. In the ratio of the stress is the demand for increased resistance: such cases form bulkheads, and if the displacing force be great, the ends of the bulkhead require reinforcement through additional abutments.

FIG. 853.

The force of occlusion applied to a bridge anchored by terminal bars tends to swing the piece as though held in trunnions—moreover, to draw the bars from the anchorage teeth (Fig. 854, *A*). It is evident that to securely fasten such pieces the ends must be so formed, so placed, and of such size as to resist tendencies inherent in this pattern of bridge (Fig. 854, *B*, *C*).

FIG. 854.



To ensure the stability of a bridge it should be so made and so attached to its abutments that neither bridge nor any part of it has any movement independent of the abutments. Violations of this rule are found where caps are made of too thin metal, which by stretching or breaking permits slight loosening of the piece; the retaining cement is worn away piecemeal, and the space left is filled with fermenting débris: decalcification of the enamel and caries ensue.

Retaining caps are frequently made with merely a narrow band encircling the labial wall of the neck of the tooth. Unless these bands are made of rigid metal they will become loose, and they acquire a slight mobility upon the tooth; the underlying cement is dislodged, and it is not uncommon to find an area of decalcified enamel beneath them.

Bar anchorages should be so formed and attached that they become mechanically a continuation of the abutment itself.

With decreasing amount of resistance offered by the abutments should be a decrease of the extent of masticating or incisive surface; for example, two abutment crowns, a firmly fixed molar and cuspid, having healthy root support, may have the original amount of masticatory surface restored; but if the fixation of the abutments be less rigid or not in so good a physiological condition, the amount of the surface should be diminished.

Physiological Aspect.—The physiological aspect of bridge-work, although belonging properly to works upon dental pathology, must form part of every treatise upon such a combination of surgery and mechanics as bridge-work represents. It includes the consideration of all of the vital relations of the abutment teeth, the contiguous parts, and, it may be, of more general vital relations. Anything directly or indirectly bearing upon the subject of dental hygiene is an item for consideration in the pursuit of this work.

The first question is that of the physiological resistance of the abutments, and the danger, immediate or remote, of any disease process occurring in or about them. These include the possibilities of enamel

decalcification, caries of the dentine, eburnitis, any stage or degree of pulp irritation or inflammation, and any variety or degree of pericementitis. The possibility or probability of any one or more of these conditions arising must be a governing factor in determining the form of bridge to be applied.

Due consideration must be given to the possibility of disease process of the soft tissues—whether through too great or improper character of contact the gums be irritated by pressure or the contact of sharp edges, or the forming of spaces in which decomposing food may act as an irritant to mucous surfaces.

The decalcification of an enamel surface embraced by a portion of the bridge arises from lactic acid, the product of a specific fermentation of starchy foods gaining access to surfaces from which it is not removed, due either to the carelessness of a patient or to his inability to remove it owing to the peculiar situation.

Under narrow bands or where the retaining cement is exposed to the access of the fluids of the mouth, after a variable length of time it is mechanically dislodged, or it may be dissolved, leaving a space which fills with fermenting materials inaccessible to the tooth-brush. Pockets made by some surface of the bridge and an uncovered enamel surface become filled with fermenting deposits, which if not removed produce decalcification of the enamel surface. If these spaces remain undetected, caries follows, and it may be exposure and disease of the pulp, and subsequently of the pericementum.

Bridges should be so made and so placed that even less opportunity is given for the action of the products of fermentation upon tooth-tissues than before the placement of the bridge.

Any part of a tooth's surface which, through the fixing of a bridge, is placed beyond the access of the ordinary cleansing agents employed by patients should be protected from the ingress or contact of ferments or fermentable material by having a portion of the bridge act as an impenetrable and impermeable shield.

Another possible source of disturbance, one which may affect the nutritive functions of the pulp, will be found in teeth which have been denuded of enamel by their preparation to serve as abutments. The pulp may receive abnormal stimulus through the irritation of the contents of the dentinal tubuli or have an increased conduction of thermal influence, and secondary deposits may occur in the pulp.

The question of subsequent pericementitis in an abutment tooth, if the tooth be pulpless, depends largely upon the thoroughness with which the pulp-canal and dentine have been sterilized, and the completeness with which an impenetrable barrier has been placed between the pulp-canal and the tissues of the apical space; second, upon the former condition of the root, as a part once inflamed has an increased susceptibility to a recurrence of inflammation; third, overstraining the abutments, causing a chronic pericementitis and a gradual loss of the alveolar tissues; fourth, the existence of a dyscrasia which may in the future cause phagedenic pericementitis. Should any of the pathologic states be present, they must receive appropriate treatment before the fixation of the bridge. Should they arise subsequently, each must receive therapeutic aid.

The muco-periosteum of the alveolar ridge most suitable for the contact of bridge pieces is that exhibiting firm texture and pink color. When placed in mouths exhibiting a catarrhal condition increased care is demanded that there be no inaccessible pockets in which fermenting material may find lodgement.

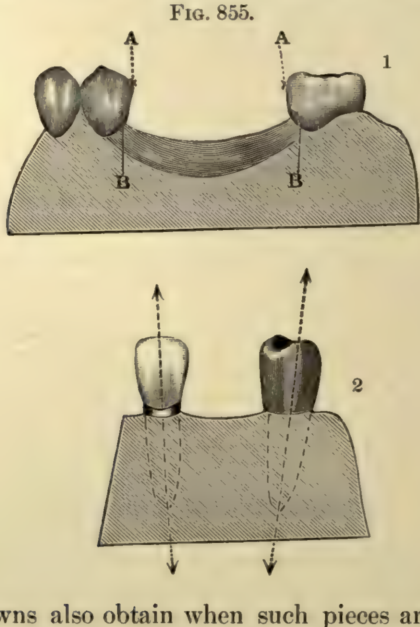
When the retaining medium of a bridge is zinc phosphate, it should be so protected by the bridge that the fluids of the mouth have little or no access to it.

Bridges retained by bar anchorages should have the margins of the retaining fillings finished with the same care and thoroughness as if they were to subserve alone the ordinary purpose of a filling. Moreover, the margins of such fillings should be accessible to cleansing agents, for there is a probability of caries resulting from non-observance of the rule.

Contact of any portion of a bridge with the natural gum should be of such a nature that there is established no source of irritation to it, either through roughness, sharp edges, undue pressure, or inaccessible pockets.

Preparation of Abutments.—First and most important, any root or tooth which it is designed to make the abutment of a dental bridge should have such preliminary treatment as will bring it to a condition of health. The directions given as to the preparation of roots for the reception of artificial crowns apply with redoubled force when these roots are to be abutments. The same requirements as to perfect adaptation

FIG. 855.



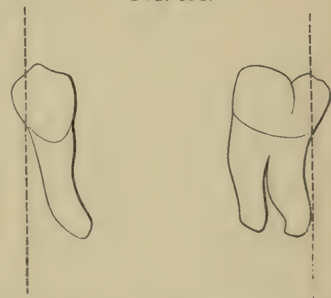
of individual crowns also obtain when such pieces are to serve as the abutment crowns of bridges. The contact of every crown edge with its base should be perfect, and each crown should represent as carefully made and adjusted a piece as were the same crown to stand alone.

After all preparations of the bases have been made, so that single crowns may be properly adapted, there arises the consideration of the

mutual relations between the individual crowns. It is evident that as these pieces are to be rigidly joined to one immovable piece, the abutments must be so shaped as to permit placing them when so joined. The next consideration is, therefore, the dressing of the walls of the abutment until they are parallel or less than parallel, for it is also evident that if the distance *A A* be less than *B B* (Fig. 855, 1), joined cylinders which shall slip over *A A* will not be in contact with the points *B B;* and this latter is an essential condition in properly adapted abutment crowns. (See also Fig. 856.) With post crowns it is evident that the axis of the root-canal, the root-walls covered by the collar, and the walls of the other abutment must all be parallel or they cannot be perfectly set when rigidly united; the lack of parallelism is shown in Fig. 855, 2.

The extent of the lack of parallelism between the axes of the abutments are noted before preparing the latter for the reception of the abutment crowns. A pair of accurate callipers will be found useful to make measurements to determine the amount of dressing required. Applied first to the longest distance between the abutments, usually at the necks of the teeth, this length is laid upon the parts of shortest difference. The portions of the tooth necessary to equalize the lengths are then dressed away. Should the teeth diverge, the shortest distance is first measured, and the dressing of the walls proceeded with as before.

Fig. 856.

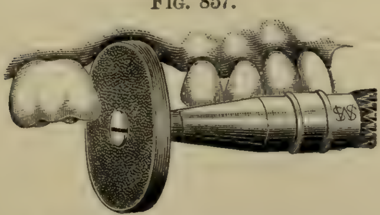


To allow of slight aberrations in adjusting it is usual to reduce the walls to something less than mutually parallel lines.

The dressing or shaping of the walls of abutment crowns when these latter are covered with enamel is readily done by means of diamond disks: these are thin disks of copper charged with diamond dust (Fig. 858).

The stump corundum wheel having a brass tire, makes the wheel safe-edge, so that it can be used to grind off the sides of a natural crown, as for a cap crown, without risk of wounding the gum (Fig. 857). When

Fig. 857.



Safe-edge stump corundum wheel.

Fig. 858.

the sides of the wheel become worn by use the edge of the tire can be readily turned off with a sharp tool. Size of wheel, 1 inch diameter.

Properly adapted corundum wheels may also be used for the purpose. The safe-sided diamond disk is to be employed where a space is to be cut

42

between adjoining teeth. The tooth to be shaped is first squared on four sides by means of disks, and given a slightly pyramidal form; the angles of the pyramid are then rounded (Fig. 859).

In forming the retaining slots for the reception of abutment bars, they and the bar itself should have a form which shall prevent either the withdrawal or movement of the bar in its socket. The bar is to be so shaped and anchored as to form mechanically part of the abutment tooth. It is obvious that cylindrical or prismatic bars would have by their form a liability to be withdrawn if the bridge or its abutment should be subjected to such stress. For example, see Fig. 860. Were the

FIG. 859.

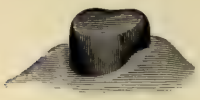


FIG. 860.

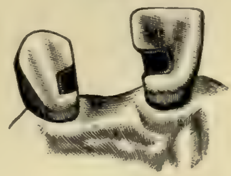


FIG. 861.

bars of this suspension tooth made of cylindrical or prismatic wires the movements of the abutment teeth through the force of mastication, and also the stress upon the bridge tooth, would tend to strip the fillings retaining the bar from the latter. Moreover, a cylindrical bar would, when the bridge tooth is subjected to stress, act as a trunnion upon which the bridge is swung, and the bridge tooth would rotate upon that axis. Shaping the bar, as in the cut, as a pyramid having its base in the farthest wall of the abutment cavity, would prevent, first, the moving of the abutment teeth away from the bar; second, would prevent the bar from turning upon its axis.

The cavity in the tooth it readily formed by means of dentate fissure burs: these are employed to make the slot, which is then enlarged and shaped with burs of the inverted cone pattern. In many cases cavities are already existent, which are enlarged to the proper dimensions and given the form seen in Figs. 860 and 862. It is advisable, where possible, to have the edges of such cavities extend laterally to an extent which shall admit of ready cleansing by means of the tooth-brush.

FIG. 862.

Cavities much larger than the proper size of a retaining bar receive a preliminary filling which is firmly anchored in the tooth, and the slot for the bar is cut and shaped in this filling. Indeed, this is an excellent practice in all cases of bar anchorage—the covering of the walls by filling material and the finishing of the margins of the same previous to placing the retaining filling about the bar. It is the only method by which the operator is assured that the essential portion of the filling is, as it should be, in absolute contact with the cavity-walls. Many operators have an unconquerable objection toward the cutting of cavities in non-carious teeth to serve as a base of retention for a bridge. Others, recognizing the difficulty of keeping the edges of retaining fillings perfectly clear of fermenting deposits, prefer to dispense with this means of retention entirely. Occasionally teeth have been implanted under favorable conditions to serve as abutments for a dental bridge.

In preparing the abutments for removable bridges they are to be formed with the great primary consideration of the adjustment of a basal fixture which shall be perfectly adapted to the abutment, protecting effectually against the ingress of pathogenic material, covering completely the tooth-structure, and immovably attached to it.

In many cases removable bridges are placed over abutments having inclined positions; the attempt at securing mutually parallel walls of the abutments is a secondary consideration. The abutment is so shaped that a single crown may be adapted perfectly; the abutment crowns of the removable bridge are then cut away until they may both be placed or removed together in a plaster impression.

Requisites of a Correct Bridge.—The first requisite is that a dental bridge must be regarded as a prosthetic appliance in its fullest sense: it should restore as nearly as possible lost form, appearance, and function. It should therefore restore the general contour lost through the loss of the teeth, and reproduce the forms of the natural crowns. The pieces should be constructed for æsthetic effect with the same care as with a plate denture. The teeth should be selected with the same regard to their proper sizes, shapes, and colors as with plate dentures. The same care is to be exercised in accurately adapting crowns as when these fixtures are made and applied as single crowns. These details are frequently ignored or deemed of minor importance—a view to which the student should by no means subscribe. The masticating surfaces are to be so formed that they will occlude perfectly with the antagonizing teeth; moreover, so that they shall effectively perform the work of actual mastication to an extent commensurate with the resistance of the abutments.

It is unwise to make the restoration in this particular too complete; that is, by restoring full cusp lengths and full occluding surfaces, as would be the case were the Bonwill articulator used and the teeth perfect anatomical representatives of the lost organs. The occluding surfaces are given a smaller area, and the cusps made shorter than with the natural teeth, so that the vertical and lateral forces upon the abutments are lessened to the required degree. When the jaws are in normal closure, however, the occlusion should be perfectly accurate or else the usefulness of the piece is lessened.

If possible, every portion of the bridge and abutments above the gum line should be easily accessible to the bristles of a tooth-brush. Tooth-substance should form no wall of a pocket inaccessible to the same implement. The bridge should cover and seal such surfaces. It should be sufficiently rigid in all its parts, and be so firmly attached to its abutments that abutments, bridge, and all its parts are a rigid piece, having not the least movement except as a single piece. It is essential that the abutments or their crowns have no movement upon one another. This necessitates that each crown shall be in itself sufficiently rigid to resist any change of form through the stress of mastication. It is not alone necessary that a crown shall fit an abutment perfectly; it must continue to do so.

As stated earlier in this chapter, there should be in the placing of a bridge a diminution rather than an increase of the opportunities for disease process arising. All edges which come in contact with the soft tissues should be smoothed and rounded. Every surface of the bridge should be free from inequalities or mechanical blemish of any kind.

Selection of the Variety of Bridge.—The many advantages afforded by bridges which may be removed with comparative ease over those irremovably attached to their abutments will no doubt lessen the application of the latter devices. Definite conditions must be present, however, to indicate the application of the class first named. Their great field of usefulness is where the abutment teeth overhang or incline toward one another to such an extent that it is inadvisable to reduce their walls to parallel lines, as in Fig. 863.

FIG. 863.

Where possible it is preferable to have the abutment crowns of barrel or collar crowns, rather than depend upon bar anchorage. Devices which embrace the anterior teeth are constructed so that the metallic portions of the fixture are not exposed through the movements of the lip. Appliances which include what are known as partial caps are to form a second choice.

When post crowns form the abutment pieces they should be mounted with collars attached either to the crowns or placed over the root itself.

Any dummy device which is not rigidly supported beyond the last

FIG. 864.

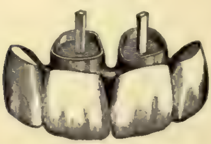
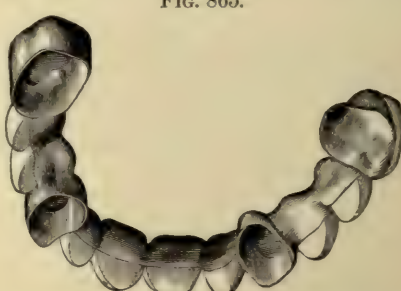


FIG. 865.



crowns is to be viewed as mechanically faulty, and not employed except under exceptional circumstances. Fig. 864 exhibits a mild form of this defective type; Fig. 865 an exaggerated one. The extreme justifiable limit of bridge-work is seen in Fig. 866.

It is to be remembered that with an increase in the number of pieces composing a bridge there is a corresponding increase of difficulty in its construction. To properly make and adjust such a bridge as is shown in Fig. 866 will tax the skill of the finished and conscientious operator.

The several devices figured in this chapter are to be regarded as representatives of classes. The ingenuity and developing skill of the operator will suggest modifications which special cases may require, and prompt him to a judicious application of features of several types in pieces he may be called upon to construct.

Fixed bridges are of several types, the simplest that having terminal

abutments of two crowns. The first class of these is for the replacement of two or more side teeth; the second, the bulkhead form of bridge for

FIG. 866.

the replacement of the incisors; next, bridges having three, then four abutments. Another class are those having some break in the continuity of the bridge arch, owing to the presence of a natural tooth which forms no part of the bridge; the next, the class of appliance known as wing or extension bridge; finally, the removable bridges, which are subdivided into several varieties.

The Manufacture of Dental Bridges.

There are involved in the making of a bridge three sets of manipulations: first, the making of the abutment crowns; second, the manufacture of the intervening dummies; and, third, the uniting of the several parts into one rigid, highly finished piece. From beginning to end it includes a series of small but important details. In the degree that care and attention are devoted to these minutiæ will be the accuracy of fit and finish of the completed bridge; neglect of them may be followed by blemish or even by disaster.

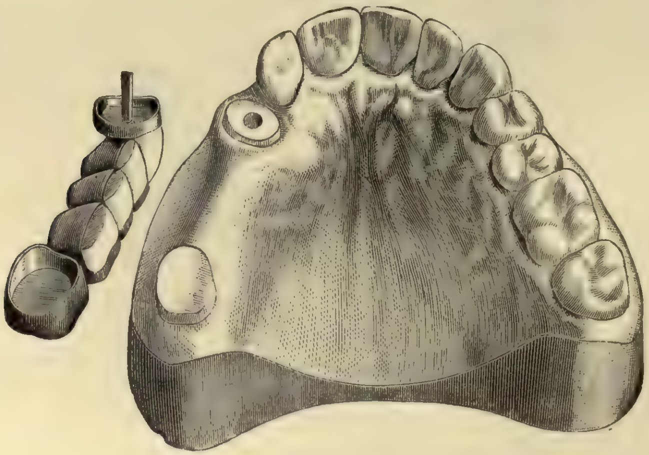
Æsthetic considerations are too frequently ignored in this class of work, but they are equally important in this as in any prosthetic operation. The completed piece should present a restoration as nearly as possible of the forms, color, size, and positions of the natural organs, and should be so articulated as to restore the lost masticating surfaces. Unnecessary exposure of gold is to be avoided, and yet the several porcelain pieces are to be so guarded that they serve merely for the restoration of appearances, receiving themselves no direct force, the latter bearing only upon masticating surfaces of gold. By this means fracture of the porcelain becomes a remote possibility.

The most usual form of bridge is that of two-collar crowns, carrying one or more dummies. A typical case is selected for example: A patient has lost the two bicuspids, first and second molar of the side. The cuspid and third molar are the seat of extensive caries. These teeth are treated and shaped as described under the head of preparation of roots given the forms seen in Fig. 867.

A collar crown is fitted to the cuspid; a hollow gold crown to the molar. (The methods of constructing these crowns will be found in Chapter XVIII.) Not uncommonly the latter crown is made of too thin

metal; all barrel crowns serving as abutment crowns of bridges must be rigid enough to prevent any change of form arising from the stress upon it received through the body of the bridge. Not infrequently crowns

FIG. 867.

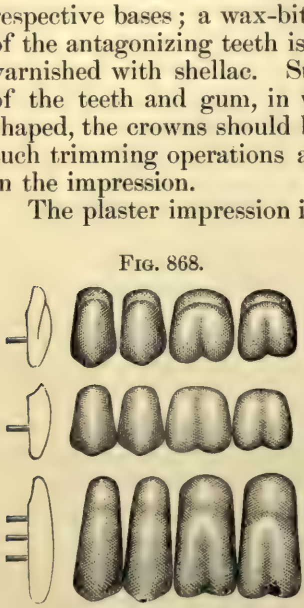


made of thin gold are seen to break or to become bent under this strain. All of the soldering on these crowns should be done with 22-carat solder.

The crowns when made and carefully finished are adjusted to their respective bases; a wax-bite taken of the entire side; a wax impression of the antagonizing teeth is made, carefully poured, and the plaster teeth varnished with shellac. Succeeding this, a plaster impression is taken of the teeth and gum, in which, if the abutments have been properly shaped, the crowns should be withdrawn. If not, it is better to perform such trimming operations as will permit the withdrawal of both crowns in the impression.

The plaster impression is varnished and a plaster model made. When separated the wax-bite is placed on the model and the cast of the inferior teeth carefully set in position and mounted in the articulator.

FIG. 868.



Porcelain facings are selected the color of the cuspid porcelain (Fig. 868). The necks of the facings should just touch the gum, their cutting edges to be in contact with the antagonizing teeth.

The following description is that of the method usually practised by the writer; it is somewhat more tedious than those generally followed, but the increased accuracy of articulation and better protection of the porcelain recommend its employment. The general process may be applied to the making of the masticating dummies of any bridge. In fact, the making of a bridge consists essentially

in constructing two or more crowns of the types described in Chapter XVIII., and uniting them with the dummies in such a manner as to form a rigid fixture.

Each facing is ground and fitted to the models as though a plain tooth were being fitted to a plate, its upper edge just resting upon the gum. The cut surface of the porcelain is now smoothed and polished. The occluding edge of the facing is to be ground to within less than one-sixteenth of an inch of contact with the antagonizing teeth, and bevelled toward

FIG. 869.

FIG. 870.

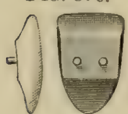
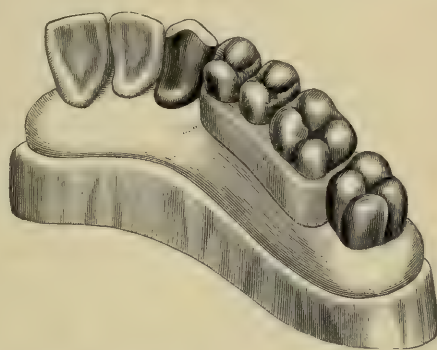


FIG. 871.



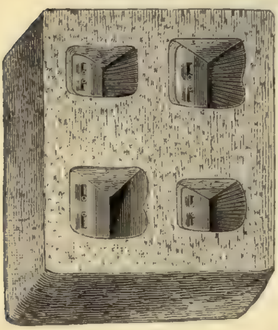
its outer edge, the bevels to be long (Fig. 870). Stays of pure gold or of crown metal are to be fitted to the facings, extending from the outer edge of the occlusal portion to near the gum line. The facings are arranged in position on the model, and held by means of wax melted about their bases. The surface of the latter and that of the antagonizing model are to be varnished. A batter of soft plaster is built against the stays and above the cutting edges of the teeth; it is to extend from abutment to abutment, and be broader than the masticating surfaces of the proposed dummies. While the plaster is still soft the teeth of the antagonizing model are brought into occlusion. As soon as the plaster has set its surface is scraped down uniformly to about the thickness of No. 30 plate. At its outer edge it is scraped away until the edge of each dummy stay is exposed. The width of the plaster block is to represent the area of the masticating surface of the dummies, and is cut to the desired width. Saw-cuts are made marking the individual teeth. The irregular plaster surface is now carved into cusps and sulci, according to the elevations and depressions made in the plaster by the tips of the antagonizing teeth. (See Fig. 871.)

An anatomically correct occlusion may be moulded by mounting the models in a Bonwill articulator, and carving cusps and sulci in the plaster, so that, when the movable jaw of the articulator is moved, every tooth of the side is seen to be in occlusion. This premises, however, that full models of each jaw be mounted in the articulator.

The plaster block is now varnished, and when dry a die of Babbitt metal is made of it. A cap of No. 30 pure gold is to be swaged, fitting the surface of the plaster and joining, but not overlapping, the abutment crowns. (See Fig. 820.) The piece so formed is placed on the die and divided into pieces at the grooves marking the individual teeth by

means of a fine saw-blade. The caps are boiled in acid solution, and are filled flush by melting 22-carat solder in them. The plaster holding the facings to the model is removed and wax substituted. The outer edges of the caps are ground or filed, so that they are in accurate contact with the edges of the stays and occlude accurately (Fig. 869). Their lateral edges are dressed until they join one another closely and there is an accurate joint with the abutment crowns. The several pieces (caps and facings) are boiled in the acid solution. A thin layer of wax is placed on the model between the abutments, just sufficient to hold the facings in position; the caps are set on the facings and attached by means of adhesive wax; while the latter is still soft the caps are placed in their correct positions in relation with each other and with the antagonizing teeth. Each facing with its cap attached is removed from the model. A triangular strip of mica may be attached to the sides of each, as recommended by Dr. R. W. Starr. The pieces are then invested in a common investment (Fig. 872). A number of pieces of 24-carat gold, having decreasing width, are cut; all the surfaces are covered with borax. The depression enclosed by the mica strips and cap is filled with these pieces, and the surfaces so made are covered well with 22-carat solder. The investment is heated on a furnace, and next upon a charcoal bed, using a blowpipe flame directed against the back of the investment. When the entire investment is heated bright red, the solder beginniug to fuse through the transmitted heat, a fine blowpipe flame is directed against the gold until the solder flows freely, adding more and more of the latter until each depression is filled, and giving a smooth-surfaced gold block. When cold break away the investment and boil in the acid solution.

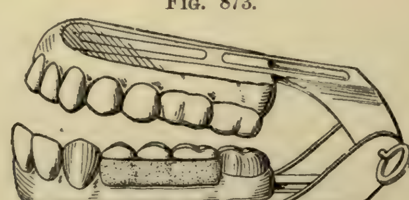
FIG. 872.



The method described will furnish the most accurate occlusion and a minimum exposure of gold, together with perfect protection of the porcelain and a minimum risk of checking the facings during soldering. A similar method is that of the Hollingsworth system.

To Make the Grinding Surface of a Bridge in One Continuous Piece.—After having crowned the teeth for the attachment of the bridge, take

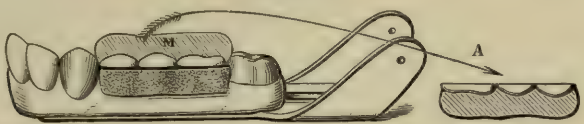
FIG. 873.



a bite in modelling compound, remove the compound, place the crowns in their impressions, make a cast of sand and plaster, and place on

an articulator; now put moldine between the abutments instead of wax, and get the articulation with cusp-buttons the same as for plate teeth (Fig. 873). Then to remove the buttons without destroying the articulation, make a cup by pouring Melotte's metal, as cool as it will flow, on the face of the cusp-buttons. Heat the pouring lip of the ladle and use it to smooth out the half-solidified metal, as with a soldering iron (Fig. 874). Then place a thin coating of moldine upon the moulding plate. Remove the cup from the articulator with the cusp-buttons in place (Fig. 874, *A*). Transfer the cusps by

FIG. 874.



inverting the moulding plate (Fig. 875), and turn the cusp buttons out upon the moldine on the plate with the grinding-surface up (Fig. 875), and they will occupy the same relative positions as when on the articulator.

Now place the large rubber ring around the buttons on the plate, and proceed to make a die with Melotte's metal, as before described (Fig. 876). When cool, remove the buttons and coat the face of the die

FIG. 875.

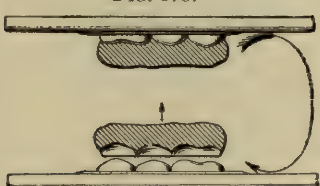
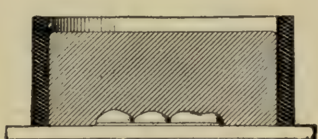


FIG. 876.



with whiting. Invert the die and raise the rubber ring sufficiently high on it, and make a counter-die with the same metal by pouring as cool as possible (Fig. 877).

This gives the male and female dies with which to swage the continuous grinding-surfaces. Then proceed to swage the gold plate in one

FIG. 877.

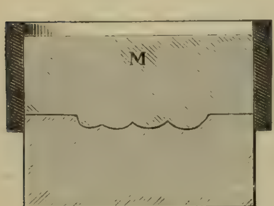


FIG. 878.

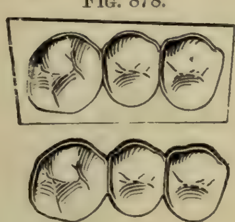


FIG. 879.

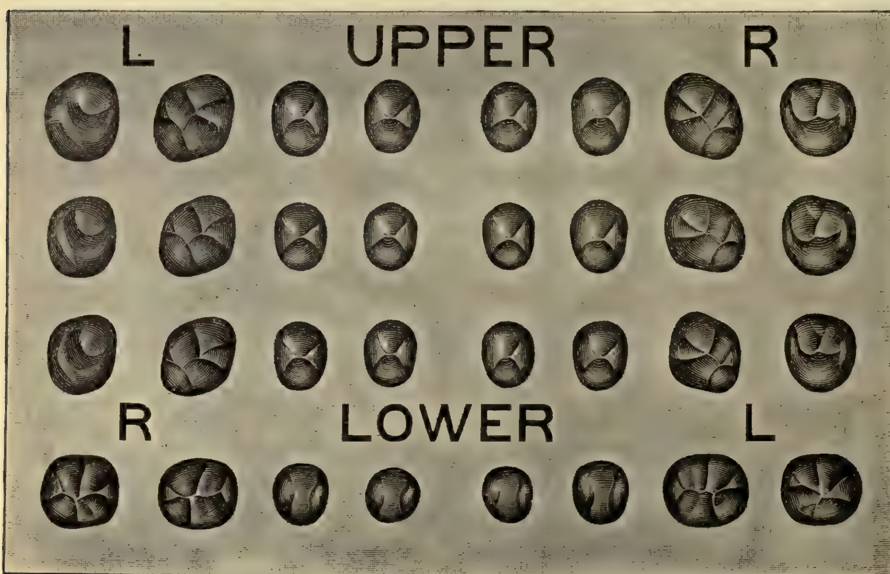
piece (Fig. 878), annealing as often as necessary. Trim off the surplus plate (Fig. 878), and place in position on the articulator. Cut the cusps out on the buccal face to avoid showing the gold (Fig.

879), grind the porcelain facings to fit the cusps, and back with gold, No. 34 or 36, letting the gold come to the cutting edge, the same as in a single crown as before described.

If there is a space between the cutting edge and the porcelain, place a little wax in the joint to keep out the plaster investment, invest, remove the wax from between the joints, flux, and solder.

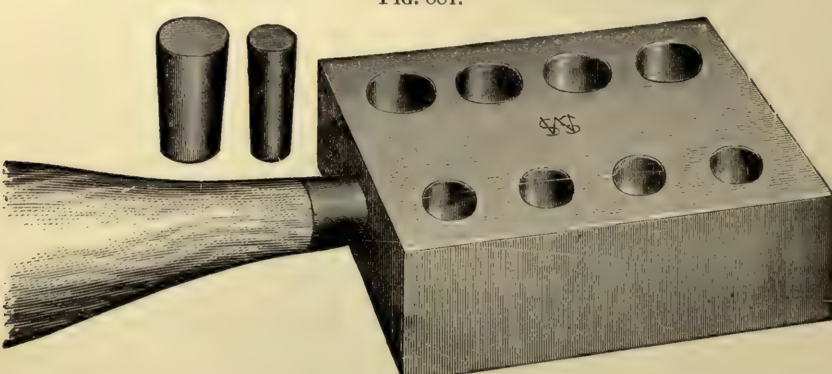
Facings for Making All-gold Bridge.—If it is desired to make an all-gold bridge, select the proper facings from the set, make a die of

Fig. 880.



Melotte's metal, and swage up, the same as in the continuous bridge before described, and mount gold facings in place of porcelain.

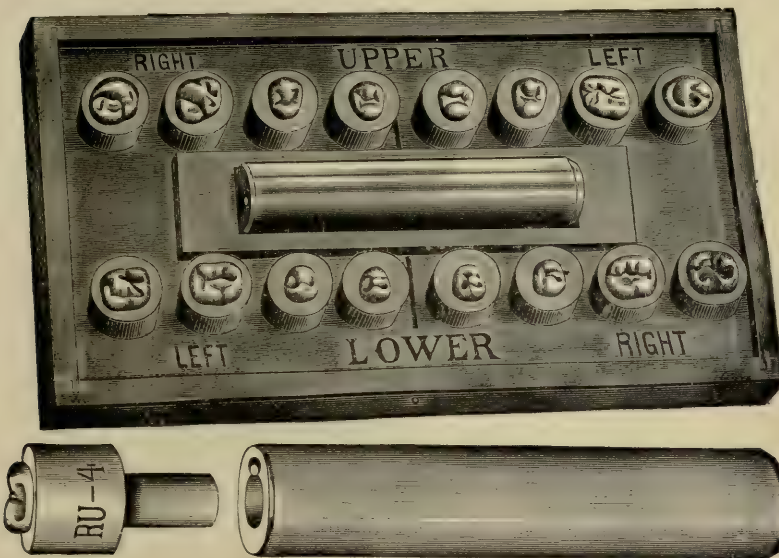
Fig. 881.



The usual method of forming the dummies is by the brass or steel dies or plates to be had from dealers in dental supplies (Fig. 880).

Appropriate forms of crown caps are selected, using small leaden hubs (the plate for forming the hubs is shown in Fig. 881): the latter are

FIG. 882.



driven into the depression of the die-plate, forming small lead dies. A piece of pure gold, No. 30 or 31, is pressed into the depression the lead die set over it, and a cap is swaged, which is then filled with 22-carat solder.

The under surfaces of these filled caps are ground flat on the side of a corundum wheel; the facing, which has had a backing adjusted, is ground square, making a close joint with the cut surface of the metal cap, their outer edges in a line

FIG. 884.

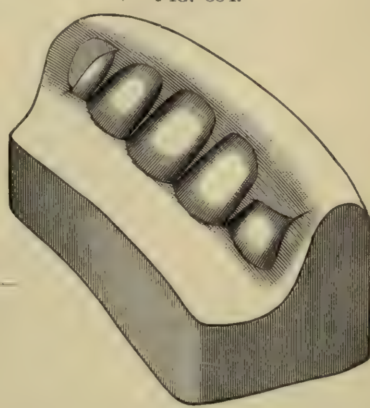


FIG. 883.

(Fig. 883). They are next adjusted to occlusion as described, invested, and soldered after the same manner (Fig. 884).

When the steel dies (Fig. 882) are used the counter-die is formed by driving them into a block of soft lead.

Another method occasionally practised is as follows: Instead of separating the swaged cap-piece into several teeth, it is filled flush with solder, ground flat at the parts which are to rest upon the

porcelain facings. The latter are backed and ground to positions. Next, waxed to place, they are invested, the space beneath the caps filled with pieces of 24-carat plate, and covered with solder; the piece is heated and soldered. The contraction of the large mass of solder tends to bend or distort the gold cap, and it increases the danger of fracturing the porcelain.

After making the individual dummies it is advisable to unite them in one piece before attaching to the abutment crowns. They are all adjusted to the plaster models and a stiff wire laid along their under surfaces, which are then covered by adhesive wax to rigidly maintain the relative positions of the pieces. They are then invested, and united to one another with 20-carat solder. When cool the piece is smoothed and buffed. This operation may be more perfectly done at this stage than in the finished piece.

Many operators, having made the model of investing material instead of plaster, now set the block in position, wet the model, and cover the block and abutment crowns with more of the investing material, leaving the joints to be soldered exposed. The case, dried carefully to avoid separation of the new from the old investment, is heated and the dummy block united to the abutment crowns with 20-carat solder.

Greater accuracy is assured by an adjustment of the pieces in the mouth before uniting them.

The abutment crowns are removed, and, with the dummy block, boiled in the pickle, washed, and dried. The crowns placed in proper positions on their bases, a block of soft wax is attached to the base of

Fig. 885.

the dummies, and it is pressed to its proper position in the mouth, testing the occlusion. A plaster impression is now taken, covering the bridge pieces just enough to secure their withdrawal in the impression.

Should the several pieces not be removed in the impressions, they are detached separately and set in their correct position. (See Fig. 885.)

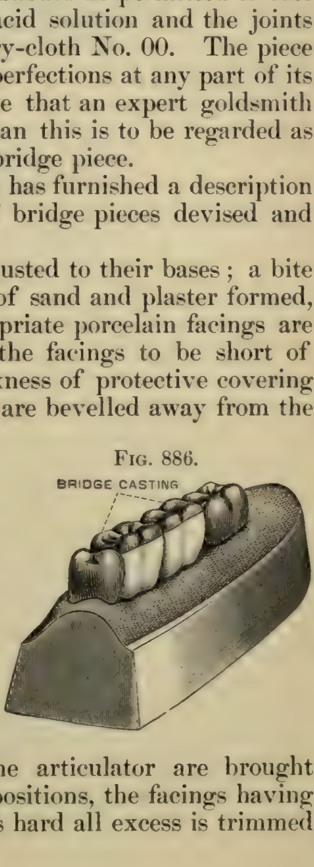
The plaster of the impression is scraped away until it serves merely as a guide and to retain the pieces in their correct relative positions (Fig. 885). The wax underlying the dummies will be withdrawn in the impression : it is to be permitted to remain, so that the investing material to be poured into the impression will not enter the soldering space. The plaster surfaces are varnished and a cast poured of investing material ; when the latter is hard the impression is cut away. Additional investment material is placed to protect the porcelain and the solder of the body of the bridge, but leaving exposed entire the joints between the latter and the abutment crowns. A sufficient amount of 20-carat solder —or, unless the operator be an expert, 18-carat solder—is placed along the joint to be soldered. The investment is to be first thoroughly dried, and the heat increased gradually until it is red hot. The injunction to heat slowly is given, as not infrequently too rapid a heating will prevent the gradual escape of steam from beneath barrel crowns, and may lead to their displacement.

When the case is at a uniform red heat turn the fine blowpipe flame upon the joint and flow the solder, adding more of the latter if necessary to fill the joint flush. The investment should be permitted to cool slowly. When cold it is boiled in a strong acid solution and the joints made smooth by means of fine files and emery-cloth No. 00. The piece is to be so finished that there shall be no imperfections at any part of its surface. The finish should be of such a type that an expert goldsmith would approve of it ; any lower standard than this is to be regarded as a faulty and imperfect finish for a crown or bridge piece.

Dr. M. W. Hollingsworth of Philadelphia has furnished a description of a method of casting the metallic body of bridge pieces devised and followed by him for several years.

The abutment crowns are made and adjusted to their bases ; a bite and a plaster impression are taken, a model of sand and plaster formed, and an articulating model mounted. Appropriate porcelain facings are selected and adapted, the cutting edges of the facings to be short of occlusion sufficiently to admit the usual thickness of protective covering of gold. The palatal surfaces of the facings are bevelled away from the pins on all sides. Stays of 24-carat gold No. 27 are adapted ; the facings are invested and soldered to the pins. When cool the projecting ends of the pins are ground away.

Fig. 886.



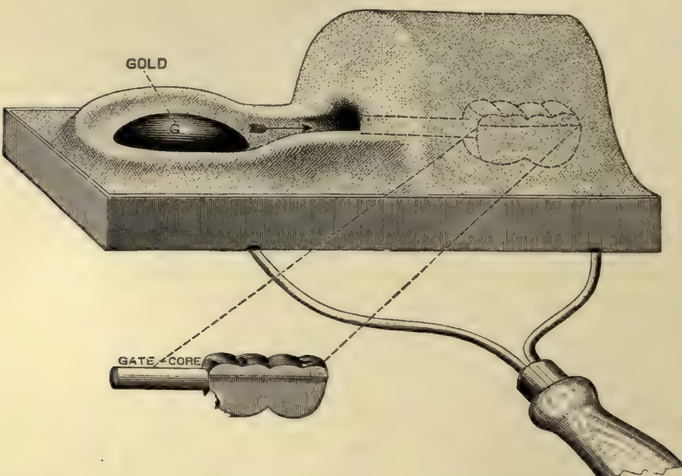
Between the abutment crowns on the model a mass of softened wax is placed : it is preferable to employ one of the wax compounds, wax and gutta-percha, or wax and paraffin. The surfaces to be covered by the wax are moistened to prevent their adhesion to crowns or model.

While the mass is soft the jaws of the articulator are brought together and the facings set in their proper positions, the facings having also been moistened. When the wax mass is hard all excess is trimmed

away, and it is carved into the form of the future bridge body, special care being bestowed upon the accuracy of occlusion (Fig. 886). The wax mass, thoroughly chilled, is then lifted from the model and each facing detached and set aside. At one extremity of the wax pattern a cylinder of wax, one-eighth of an inch by one-fourth of an inch, is cemented.

In a shallow sheet-iron tray having a handle a mixture of marble-dust and plaster investment, mixed thin, is poured. At the square portions of the tray the wax pattern is set, with the projecting tongue on a level with the surface of the investment; the investing material is built over the wax pattern, covering it to a depth of about half an inch, the small projection to have its end exposed, as shown in Fig. 887.

FIG. 887.



In the flat section of the investment a concavity is carved to serve as a melting-pot. Running from this depression, and joining the wax terminal of the bridge pattern, a gutter is cut. The investment about the wax terminal is cut so that it has a bell mouth; this is to permit the ready entrance of the molten gold to the mould. The entire piece is brushed to free it of any loose fragments of sand. The tray and investment are now heated until all of the wax pattern is burned out. An excess of 22-carat gold is placed in the melting-pan (the depression), and a large blowpipe flame directed against the gold and investment. As the success of casting will depend largely upon the fluidity of the gold at the moment of pouring and the weight of its column, the heat is maintained until the gold is freely molten, when by a turn of the hand the pan is inclined, permitting the gold to run from the melting-pot into the mould, filling it to the mouth. When cool the gate cylinder is sawn off and the bridge body accurately fitted to position between the abutments.

The outer wall of the bridge body is marked into depressions into which the facings fit accurately. The pieces are boiled in the sulphuric-acid solution, dried, and the facings attached in position by means of

wax flux melted along the joint lines. The piece is invested, having the investment thin over the facings and articulatory faces of the bridge. At the joints, between the stays and bridge, at the necks of the facings, small pieces of 18-carat solder are placed, and the investment heated from the outer side until the solder flows, uniting stays and bridge perfectly. When cool the piece is boiled in acid, smoothed, polished, then adjusted to position on the model. More investment is added, and the bridge is united to the abutment crowns as before described.

The Bulkhead Bridge.—Another class of cases frequently seen are comprised in those for the replacement of the superior incisors, the anchorages being the roots of the cuspids. As a rule, it is necessary in order to gain adequate mechanical support for such a piece to remove the crowns of the cuspids. For the correct application of a bridge there should be so little absorption of the alveolar plate, so slight a loss of fulness of the gum, as to permit the adaptation of plain teeth of the proper size and form.

FIG. 888.

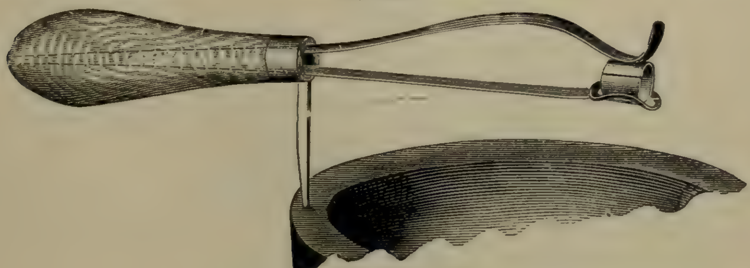
In the event of it being necessary to employ gum teeth a fixed bridge is contraindicated, but it is still quite possible to adjust a removable piece of a type to be described later.

It is possible to form the abutment pieces of partial cylinders attached to the abutment teeth (Fig. 888), but this principle, as above implied, is faulty both mechanically and hygienically. Should it be decided to utilize this type of anchorage, it is advisable to form the shell anchorage after Dr. Mellotte's method.

"It is necessary to first reduce all of the mesial and distal walls of the teeth to parallel lines, so that pieces which pass over the crowns will be in close apposition with the necks of the teeth.

"As there may be grounds for objection to cutting off sound teeth, a shoulder cut on the lingual portion of the cuspid, and suitably shaping its side to permit a close fitting of the collar just under the free margin of the gum, will avoid that necessity. A narrow strip of pattern tin, bent tight around the tooth neck and cut through with a knife at the

FIG. 889.

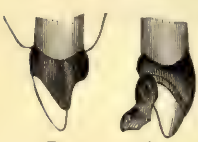


lap on the labial surface, will serve as a measure for the length of a strip of 22-carat gold plate, No. 29 thick, and as wide as the length of the distal side of the cuspid. The ends of the gold are then squared, and with round-nosed pliers brought evenly together to be held in flush contact by the soldering-clamp shown in Fig. 889. The soldered collar,

with its joint side inward, is then adjusted on the tooth as accurately as possible, giving slight blows with a mallet until the collar touches the gum, when it should be marked to indicate the necessary trimming to conform it to the gum outline. After it has been thus trimmed, the edges bevelled, the labial part shaped with contouring pliers, the labial part cut down to about one-tenth of an inch in width, the collar is again driven on, and will appear as seen in Fig. 890. A stump corundum wheel is then used to grind a shoulder on the lingual surface of the tooth, grinding also the edges of the collar flush with the shoulder. The collar is again removed, and a piece of thin platinum plate, about No. 32, sufficient to cover the lingual surface of the tooth, is caught on the lingual edge of the collar by the least bit of solder, and all put in place on the cuspid. (See Fig. 891, *A*.) The platinum should now be burnished on the shoulder and over the tooth and collar to the extent shown by the lines in Fig. 891. After trimming to those lines, and careful replacement and burnishing on the tooth, the collar and half cap are removed, filled with wet plaster and sand, and the platinum soldered to the gold. It is then placed on the tooth, burnished into all the inequalities of the tooth, very carefully removed, invested, and enough solder flowed over the platinum to cover and give it strength. Fig. 891, *B*, shows it complete on the cuspid.

FIG. 890.

FIG. 891.



I have often made such collars in less than an hour, and in any case time must be made subservient to exactness of fit and adaptation to the end in view."[1]

Additional fixation may be given these collars under favorable conditions through Dr. Litch's expedient of the pin anchorage. In the centre of the shoulder portion of each cap, before stiffening the cap, a hole is drilled, the drill passing into the tooth for a short distance—enough to furnish a socket for a piece of platinum screw, but not deep enough to endanger the pulp. A small length of screw is passed through the opening into the tooth and projecting a sixteenth of an inch or more. Adhesive wax is flowed over the end of the screw and the collar cap; the caps are withdrawn and invested. A piece of plate, preferably of platinous gold No. 33, is annealed, perforated, and bent and filed to fit the cap, to which it is attached by means of 20-carat solder, the solder flowing about the exposed end of the screw, uniting it to the plate. The pieces are transferred to the teeth. The subsequent operations are similar to those where the abutments are made of post and collar crowns.

In the latter case the teeth are decrowned, as described in Chapter XVIII.; the pulp-canals, and when necessary the tissues about the apex of the root, are properly treated, and the ends of the roots hermetically sealed. The teeth or roots are prepared for the reception of collar and post crowns. It is necessary that the walls of the roots embraced by the collars and the axes of the pulp-canals be so trimmed that they are mutually parallel: disregard of this precaution is inevitably followed by

[1] Mellotte, *Cosmos*, vol. xxviii. p. 746.

faulty adaptation of the crowns, with its attendant evils. After enlarging one pulp-canal, insert a wire, permitting it to extend for more than half an inch from the root face, to serve as a guide line in enlarging the canal of the second abutment.

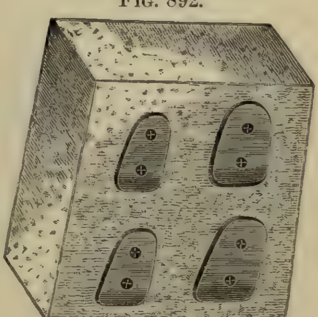
When the collars and posts have been fitted a bite is taken, next a plaster impression in which the caps are withdrawn or which clearly and unmistakably exhibits depressions into which posts and collars may be replaced with exactitude. An exact shade is secured. A model is made and an articulation mounted. A set of six plain plate straight-pin teeth are selected, matching precisely the shade tooth taken, except that the cuspids should have the yellow enamel extend farther toward the edges of the teeth than in the incisors. The teeth should exactly correspond in shape with the natural teeth, and should be of the proper length.

A block of wax is placed behind the teeth in which to imbed the pins. They are now carefully ground, as described in the chapter on Fitting of Teeth to Plates. There should be sufficient distance between the artificial and the antagonizing teeth to permit the placing of a rigid backing stay.

Should Mellotte's partial caps be employed, the distal sides of the laterals should be closely fitted to the gold, but preserving the correct forms of the teeth. The lateral surfaces of the teeth should be in close contact for at least the labial half of their length. The utmost care must be exercised in this fitting that the shape of each tooth shall be correct.

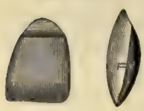
The outer wall of the impression is to be varnished, and a plaster retaining wall built against the labial faces of the teeth to retain them in position while the stays are being fitted. Each tooth is to be removed from its bed, and bevelled from the cutting edge to just above the upper pin, being careful to preserve the correct outlines of the cutting edges. Stays covering the backs of the teeth clear to the outer line of the cutting edges are fitted, and all of them to be in lateral contact. These stays are to be made of two layers—the first of 24-carat gold, No. 32, well annealed, the second of 24-carat gold, No. 26. They are burnished into accurate apposition with the backs of the teeth, covering them completely and extending to the gum line. Should it be necessary to make the stays thin, a layer of platinous gold, No. 29, is fitted over stay No. 1, and to be made of the same size. The teeth, with the stays in position, are withdrawn from the plaster wall, and are boiled in acid solution. The stays are now filed each to the outline of the palatal aspect of the tooth. The surfaces of the stays to be united are covered by borax, and the pins split to retain them in position. They are all placed in a common investment, not more than one-half inch thick, exposing the entire surfaces of the stays (Fig. 892), but covering the porcelain: 22-carat solder is coated with borax, a piece laid over each pin, one at each end of the

FIG. 892.



stay and additional pieces over the faces of the stays. The case is heated gradually until the borax fuses and holds the solder in position. A large flame of the blowpipe is directed against the base of the investment until the solder begins to fuse, when the investment is turned over and a smaller flame thrown against each stay until the solder flows freely. The investment is permitted to cool gradually, and when cold the teeth are removed and boiled in acid. Each stay is now filed, giving it a rounded form, the thickest part in the middle and curving to thin edges laterally; at the cutting edge the gold is to be thick enough to protect the porcelain facings against contact with the antagonizing teeth (Fig. 893). When in position in the mouth but a faint line of gold should be visible at the cutting edges. Each stay is to be smoothed, and all portions except those to be soldered are buffed with pumice. They are dried and returned to position on the wall upon the model; the latter is loosened from the model and then replaced in position. The teeth are reset in the wall and their joints united by means of adhesive wax. A stiff wire is now laid across the backs of the teeth and well covered with adhesive wax, so that all four teeth are immovably held together. When the wax is hard the teeth are removed from wall and model and invested. The joints between the centrals and between centrals and laterals are scraped, and a piece of very heavy pure gold, preferably triangular wire No. 16, is laid along the joints, and two small pieces of 20-carat solder on either side of each wire. The investment is heated gradually until red, and the teeth are joined together by turning a fine flame against the joints.

Fig. 893.



The abutment crowns are removed from the model, invested, and soldered with 22-carat solder, as described in Chapter XVIII. When cold the abutment crowns are placed in position in the mouth, and the incisors set in their position. A piece of softened modelling compound pressed against their palatal surfaces will hold them in their relative positions when a plaster impression is taken, in which the pieces are withdrawn. The impression is cut away until it serves merely as a means of holding the sections in position. A model is made of investing material. When separated from the impression enough additional investment is placed over the porcelain to protect it from the direct contact of the flame. The joints between the abutment crowns and the body of the bridge are scraped clean and a cream of borax painted over them. Thick pieces of plate are filed and bent to fit the angles of junction, and sufficient 20-carat solder laid over each joint to fill it flush.

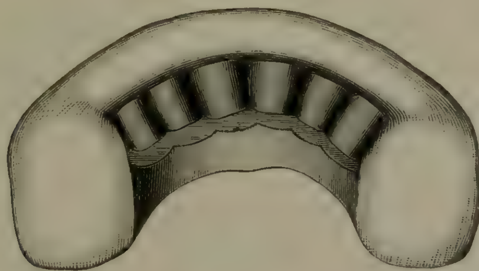
The case is heated slowly, and when the investment is at a bright-red heat the fine flame is directed against each joint until the solder flows freely. When cool the piece is finished by means of fine files, emery-cloth, and buffs, then burnished, and finally polished with rouge.

All incisor and cuspid facings are to be made after the manner described.

Some operators pour the first model of investing material and procede with the making of the dummies as described, afterward uniting the six pieces, dummies and crowns, in one operation. The separate pieces are adjusted to the model; sufficient additional investment is applied to hold and protect the facings (Fig. 894). The joints are scraped clean, a small

section of wire laid over each, borax and solder are applied, and the case is soldered as described above.

Fig. 894.



Bridges having Three or More Abutments.—With an increase of area of masticating surface, hence increase of the amount of work to be done and stress to be borne, it is advisable, where and when possible, to prepare and utilize an additional abutment, or it may be two of them. With the increase of the number of abutments there is a corresponding increase of difficulty in accurately adapting the abutment crowns. Again, with an increase in the number of pieces or sections of the bridge, the danger of distortion of the united sections through contraction of the solder or breakage of the investment becomes greater.

In trimming or shaping the abutments it is advisable to reduce each to something less than parallel sides: let them represent frusta of

Fig. 895.

pyramids or cones. A typical case of the three-abutment bridge is seen in Fig. 895.

The abutments are prepared as described, the walls of the abutments made parallel with the axes of the teeth; then each is still further reduced to ensure that all three collars may be readily set in position in the finished piece. The pulp-canals of the teeth to receive the collar crowns are enlarged more than usual. Collar crowns are fitted to the cuspid and central roots, and a barrel crown to the molar. An impression

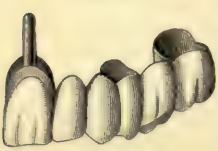
is taken with plaster, in which all three crowns should be withdrawn if the abutments have been properly trimmed. A cast of investing material is made, a wax-bite which has been taken is adjusted, and an articulation made. A lateral incisor is fitted as before described; dummies of the usual type are made and united in one block. The lateral and the dummy blocks are fitted in position and held by means of wax. Wax flux is melted in the joint between the masticating surfaces of the dummy blocks and the crowns, so that the retaining investment will not enter these spaces. An undercut is made in the model above the neck lines of the teeth; it is immersed in water, and sufficient investing material is built over the porcelain and gold to hold the pieces in position. When it is hard the model portion of the investment is cut away, so that a fine flame will enter readily beneath the gold portion of the dummies. The lines of junction are cleansed and painted with borax, pieces of plate laid over them, together with sufficient solder (20-carat) to fill the joints completely.

The investment must be dried and warmed thoroughly before heating for soldering to ensure that the two sections of investment do not separate. The case is heated from the investment side to a red heat, the hottest portions to be immediately over the joints to be soldered. Solder as usual with a fine flame.

The principle of construction is the same when a bicuspid is the middle abutment; however, in that event the crown is to be of the barrel variety, with or without a porcelain face. (See Fig. 896.)

In the soldering of these and all other bridges it is desirable to have as few joints as possible to be united in the final soldering. For instance, in such a case as Fig. 895 it is prudent to construct first the separate crowns and dummies; next unite the two crowns, the central and cuspid, with the lateral incisor; next unite the other dummies together; and finally, unite the pieces as they now are on a cast of investing material poured in a plaster impression, in which the small primary bridge and the molar crown have been withdrawn.

FIG. 896.



Cases having Four Abutments.—With four abutments about the utmost limit of available resistance is utilized, even with the most extensive bridge-work. The typical example of this variety of bridge base is seen in Fig. 897. The bridge and its abutments are guarded at four angles, the points of greatest resistance against displacement. In the illustration one abutment is seen to be prepared for the reception of a bar anchorage. This type of fixation, while lessening practically, though not theoretically, the amount of resistance afforded, renders accurate placement more easy than when a firmer abutment (a barrel crown) is employed.

The first stage of the operation after trimming the abutments, as before described, is the making of the molar crown and of the collars and posts of the cuspid crowns. In order to fit the porcelain teeth properly and artistically a wax-bite and an impression of the lower teeth are taken; next a plaster impression in which the crown bases are withdrawn. Casts are made in the plaster and wax impressions and an articulating model mounted (Fig. 898). The articulator should be

preferably that of Bonwill, to ensure the maximum of utility in the finished piece. The antagonizing teeth are varnished with shellac.

FIG. 897.

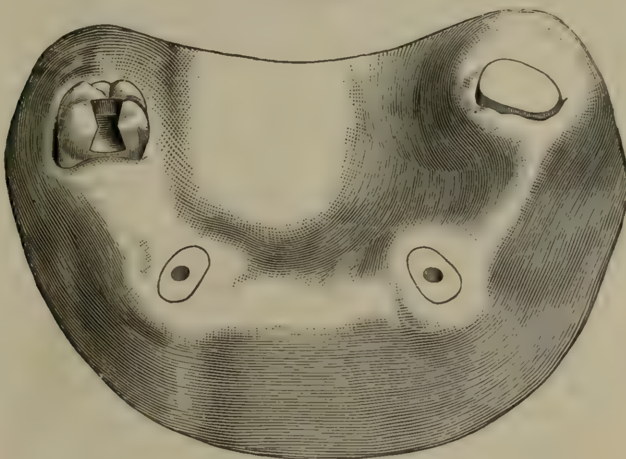
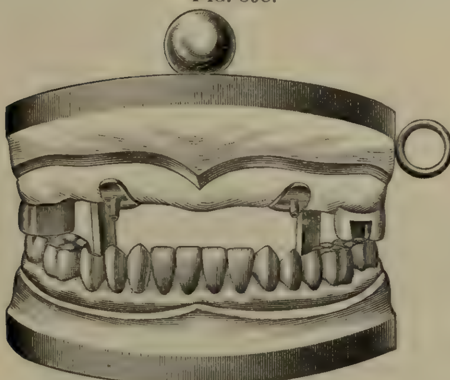
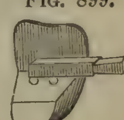


FIG. 898.



It is advisable to defer the full cutting of the groove or shaping it in the molar until it has been determined, by arranging the teeth, what should be its outlines. A set of the six anterior teeth are selected, and bicuspid and molar facings which correspond in shape, size, and shade with the natural teeth. The anterior teeth, including the facings for the cuspids, are fitted, adjusted, stayed, and soldered as for the bulk-head bridge. The bicuspid and molar dummies are made as for the first bridge described.

FIG. 899.



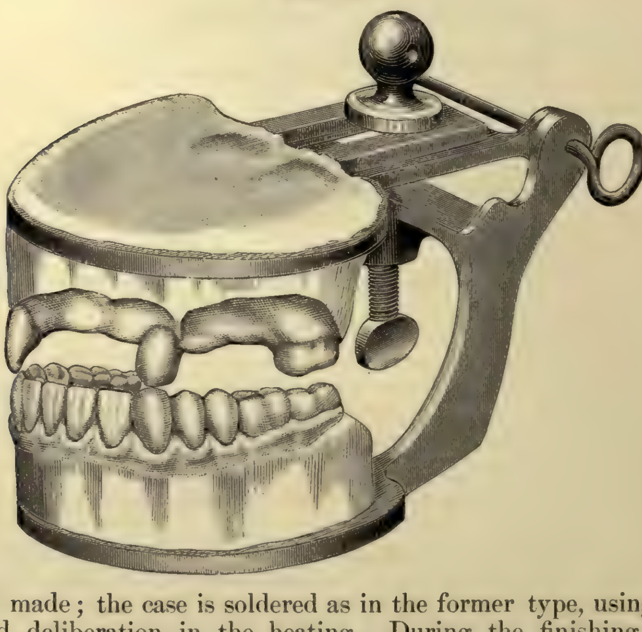
When the facing next to the slotted abutment has been adjusted and the stay fitted, the line of its wall is marked on the plaster tooth, which is carved out to the form represented in Fig. 897, and an iridio-platinum bar is fitted resting against the stay, as in Fig. 899, to which it is attached by means of adhesive wax and invested, the investment covering that portion of the bar which is to extend into the cavity.

In the event of there being rigid restriction in regard to the amount or direction of cutting the slot in the natural tooth, this may be done first and the bar and dummy be made to conform. The dummies may be now joined in three sections—first, the incisors; second, the lateral blocks, right and left. The cuspid crowns are soldered as a separate operation. The abutment crowns are then placed in position in the mouth: it may be that it will be necessary to enlarge or alter the shape of the slot in the molar abutment.

Some operators form the model of investing material so that it may serve as a soldering base. It is a safer plan to be certain of the absolute accuracy of each step of the operation, even though this necessitates the taking of several impressions.

Adhesive wax is applied to the sides of the dummy blocks which adjoin the abutment crowns; while this is still soft the latter crowns are dried and the blocks set in position, and the patient directed to bite on them. As soon as this wax is hard a plaster impression is taken in which the several pieces are withdrawn (Fig. 885). Should they not be withdrawn in the impression, it is evident that they will not when united go into place with sufficient readiness, so it is more prudent to reduce the walls of the abutment, which lock its crown, to a greater slope, then readjust the sections in the mouth, cementing them together, and again essay the impression-taking. The portions of the impression overlying the porcelain facings are cut away, and a model of investing

Fig. 900.



material made; the case is soldered as in the former type, using greater care and deliberation in the heating. During the finishing of these extensive pieces it is a wise precaution to fill the concavities of the crowns with plaster.

The following case will illustrate the imperative indication for bridge-

work, and serve as an example of the first rule given for its practice: "Is a bridge demanded by the conditions presenting?" and not, "Is it possible to apply a bridge denture?" The cuspid crowns are *in situ*—that upon the right side pulpless, that upon the left carious; the left superior third molar containing a large amalgam filling, the first superior molar of the right side pulpless, the seat of an obstinate apical abscess. The patient had worn a disfiguring plate denture, which performed no service, physiological or æsthetic. At the apex of the vault and extending to the soft palate was a large bony protuberance: this furnishes objection No. 1 against a vacuum plate. There was but little alveolar absorption; the gum at the sites of the lost teeth had a normal contour. The inferior incisors had elongated and protruded beyond their normal arch, making the adaptation of appropriate artificial teeth an impossibility. Upon mounting articulating models it was found that as the jaws of the articulator were separated the tips of the inferior incisors receded until, when the molars were separated something less than one-eighth of an inch, it was possible to adjust anatomically correct artificial incisors. The indication being that this alteration of occlusion or permanent separation of the jaws be made in order to adjust the artificial denture, it is obvious that the bite must be altered to the extent exhibited, and that the cuspids be extended until the bite rests at its four angles. Bridge-work should therefore be a demand, not a choice.

The abscess upon the molar to be obliterated; the pulpless cuspid decrowned; the carious cuspid prepared and filled, and, as its form was almost cylindrical, have its lateral walls made parallel. The filled molar was trimmed so that its walls were parallel with the other abutments.

Crowns were fitted to the molars, raising the bite one-eighth of an inch, the amount necessary; a collar and post crown to one cuspid upon the other cuspid, an open cylinder, cut away at its anterior aspect to one-eighth of an inch in width and covering completely the remainder of the crown. Shoulders were attached to the cuspid pieces in such position that all the abutments were in occlusion and the bite raised the necessary extent. A wax-bite, an impression of the lower teeth, and a plaster impression in which the abutments were withdrawn were taken. Models were mounted in the Bonwill articulator, and appropriate teeth and dummies were formed and fitted. They were united in blocks, the crowns and blocks adjusted in position in the mouth, a plaster impression taken, a base made of investing material, and the sections were united. There was some slight inconvenience following the placement of the bridge, due to the lengthened bite, which soon disappeared; the piece has been worn several years with much comfort.

Bridges with Breaks in the Continuity of their Body.

Cases present which may exhibit conditions favorable for the employment of bridge-work, except that at some part of the arch there is a tooth which may be mechanically unnecessary in the support of a bridge, and which it is the part of wisdom to leave out of the bridge structure. It may be that the tooth has such a lack of parallelism between its axes and those of the abutments that its utilization is impracticable. The

author of the only satisfactory device for application in such cases is Dr. J. L. Williams.[1]

Fig. 901.

Fig. 902.

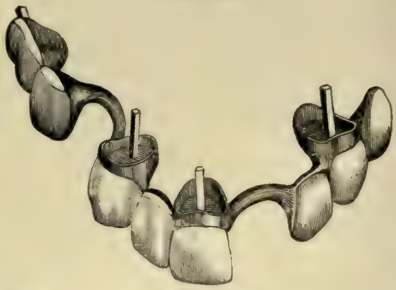


Fig. 903.

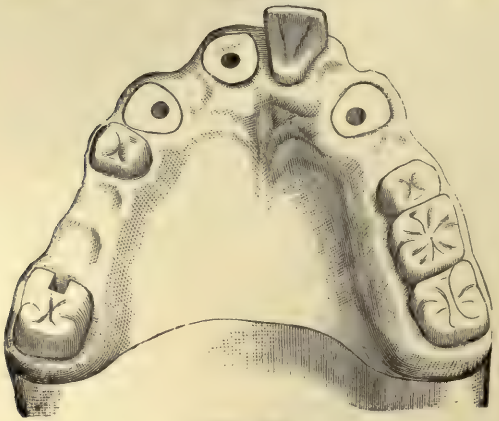


Fig. 904.

The connecting bars may be formed by annealing and flattening

[1] *Cosmos*, 1885, Dec.

slightly bars of iridio-platinum wire No. 14; these are bent about the necks of the teeth, not quite touching them, their ends resting solidly against the stays of the dummies. A typical case is illustrated in Figs. 901, 902, 903. A modified form of the same device is seen in Fig. 904. The device proves useful in such cases as the following: A crownless lateral with a good root; an unblemished cuspid; the first bicuspid absent and the second bicuspid root fit to serve as an abutment. A bridge is constructed, the lateral and second bicuspid having abutment crowns adapted; a dummy replaces the first bicuspid, and the connecting bar passes around the palatal portion of the cuspid, resting lightly upon the gum.

Extension Bridges.

The principle of construction of this variety of bridge-work is that of a portion of the body of a bridge extending beyond an abutment, and having attachment at but a single point. It will be seen that there is involved a faulty and, it may be, vicious mechanical principle. It is a variety of structure which has no counterpart in bridges as the engineer knows them.

The danger attending or following its employment is mechanical displacement of the abutment itself, the danger being in the direct ratio of

Fig. 905.

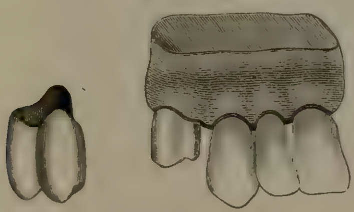
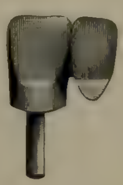


Fig. 906.



the amount of force received by and through the extension, and in the inverse ratio of the number and strength of the abutments.

Fig. 907.

A consensus of contemporary opinion places these devices in the category of abuses of bridge-work.

The mildest form of the above is seen in such a fixture as Fig. 906.

Faulty though the design may be, it cannot be denied that there are cases in which the employment of the work is justifiable.

The force received upon such a fixture as Fig. 906 necessarily tends to rotate the abutment crown or even the root itself; the same objection obtains with any fixture supported by but one abutment. The details of construction of such a piece and of Fig. 905 are evident.

Figs. 907, 908, and 909 (after Dr. Parr) exhibit a case in which the extensive work figured has its justification in the advantages afforded by

Fig. 908.

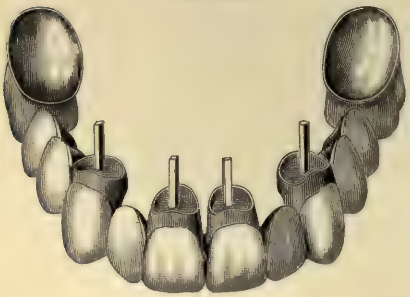
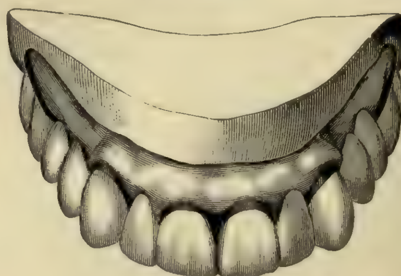


Fig. 909.



such a piece over a plate denture, so long as the abutments maintain their fixation. It is to be recognized that this, as in other extreme cases of bridge-work, is governed by matters of economy.

It is necessarily doubtful how long the abutments will persist in a condition of secure fixation, so that the question concerns the purse of the wearer: Can he afford (financially) to pay the fee for such an appliance for the term of service it is likely to afford him?

The proper construction and adaptation of such pieces tax to the utmost the skill, knowledge, and ingenuity of the expert mechanic; the novice is wise in avoiding them.

The figures illustrate the most extensive apparatus anchored to abutments which dental literature records. The crowns and dummies of such cases are constructed after the methods described. Oval plates of gold are swaged to cover a greater area of the ridge than embraced by the base of the teeth they are to support. Upon them plate teeth or all-gold crowns may be fitted, and attached to the terminal dummies.

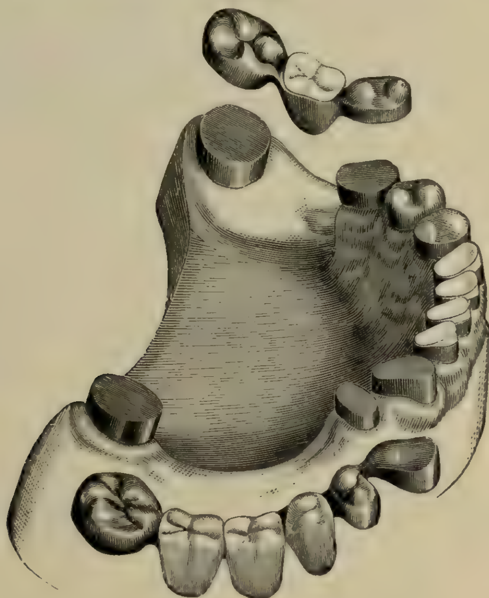
Removable Bridges.

These are devices which are so attached to abutments that they may be removed by the operator for the purpose of repair or to gain access to abutments which might possibly require therapeutic aid; again, as a means of bridging spaces to which, owing to the position of the abutments, it would be impracticable to properly adapt fixed bridges. Others are designed and attached so that the patient may remove them for hygienic considerations.

The first consideration is the perfect protection of the abutments themselves against the entrance of fermentable material, otherwise the spaces existing between the abutment, crowns, and these bases them-

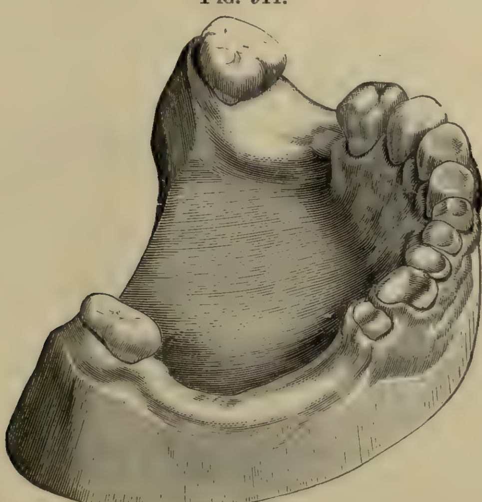
selves would, by filling with the causes of dental caries, bring about the dissolution of the abutments.

Fig. 910.



In devising this variety of bridge or in applying devices it is preferable to select those whose mode of retention and method of construction

Fig. 911.



are simple. For example, Fig. 916 would be preferable to Fig. 920, being more readily constructed.

The means of anchorage of this variety of bridge-work is either through telescoping barrels; posts fitting in sockets anchored in the roots of teeth; attachment by means of screw sockets in prepared abutments; by variously shaped sockets in the body of the bridge or attached to the abutment crowns, in which closely-fitting posts are slipped. Their degrees of simplicity are in the order named.

The first of these devices was that of Dr. R. W. Starr[1] (Fig. 910). The abutment teeth were trimmed to a form which permitted the adjustment of ferrules which were cemented to their bases.

Telescoping barrels, with properly occluding caps, are fitted over these, being cut away at such aspects as would prevent their placement in a common piece. A dummy crown is fitted between and attached to them. The pieces were set with gutta-percha.

The same principle is applied in Figs. 912–916.[2]

The illustrations explain in themselves the methods and steps of the construction.

Fig. 912.

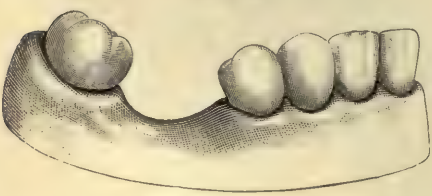


Fig. 913.

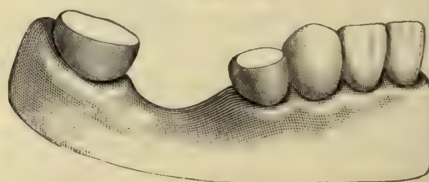


Fig. 914.

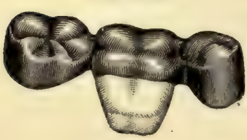


Fig. 915.

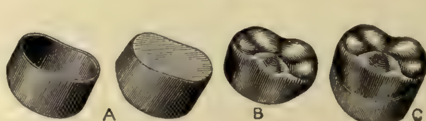
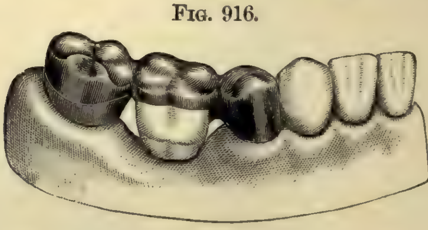


Fig. 916.



Another method of applying a removable bridge to similar cases is that of Dr. R. B. Winder. Collars are fitted to the abutments, to which perfectly flat caps are soldered. A bite and impression are taken in which the caps are withdrawn, Occluding caps are formed, which are filled flush with solder and ground flat to fit the ferrule tops. Dummies are constructed and united to one another. The caps are to be attached either by screws passing into the crowns of the abutments or else by nuts passing over screws which have been attached to the ferrule tops, over which the occluding cap is set, being perforated for the passage of the screws. It is advised that the pieces be now placed in position in

[1] *Cosmos,* 1886.

[2] F. M. Willis, D. D. S.

the mouth, held together by means of adhesive wax. Over the pieces investing material is placed sufficient to hold them together; they are then encased in investment and the caps attached to the dummy block.

Holes may be drilled through the deepest part of the cap large enough to admit the screws, and continued into the crowns as deep as the screws are long. The holes in the crowns may be enlarged and the screws slightly oiled. Zinc phosphate is placed in the pits, the bridge is set in position, and the screws thrust into the cement while the latter is still soft.

These forms of bridges are applicable where the abutment teeth incline toward one another at such an angle as to render the placing of complete cylinders impracticable or impossible. The more general employment of the same or similar methods in many of the cases which receive fixed bridges would remove many of the objections urged against the latter.

Fig. 917.

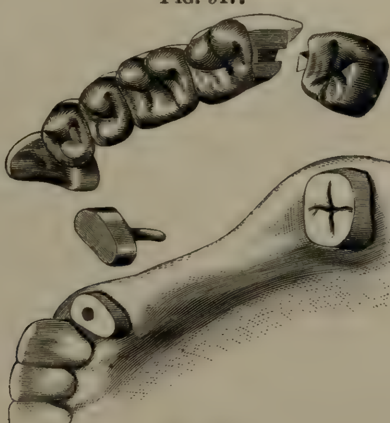


Fig. 918.

An applicable and well-devised appliance is shown in Fig. 917,[1] in which fixation of the bridge to the abutments is secured by means of a

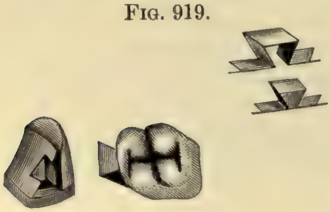
[1] Dr. C. L. Alexander.

telescoping collar placed over a capped root, its other extremity having a socket fitted to and slipped over a retaining shoulder.

A bridge held by two similar shoulders, but removable outwardly, is shown in Fig. 918: it is designed to overcome the tendency to displacement by the stress of mastication present in those devices which are inserted vertically.

Dr. Parr's method of constructing these telescoping ends is by far the simplest offered. Two pieces of platinum plate are shaped as in Fig. 919, so that one shall telescope the other: the inner one is filled flush with wax and invested; the wax is removed, the space is filled by melting gold plate in it. The outer section is filled with investment, and its walls are made rigid by flowing gold over them, or, what is preferable, adding thick pieces of plate to each side and joining them by means of 22-carat solder. The shoulders are soldered to the crowns, the slots are adjusted to the shoulders, their ends attached to the stays of the dummies. It is necessary that the slots should be immovably held against the stays to ensure their correct position in the finished piece. Soft adhesive wax is placed around them, attaching them to the backings, an unusually large amount of the wax being used. The piece is chilled and the dummies and sockets withdrawn. If both sockets come away without detachment, the piece is immediately invested; if one or both have broken away, the sharp line of fracture of the brittle cement furnishes the guide for their accurate replacement.

FIG. 919.



The writer advises that the free ends of the shoulder-piece be left as extensions which are adapted to the wall of the abutment crown, the socket piece to have similar wings which shall outline the terminal wall of the bridge body in its finished state.

In the Curtis bridge[1] (Figs. 920 and 921) the long arms (1, Fig. 921) are made of heavy platinous gold plate, the heads formed in the matrix *E*

FIG. 920.

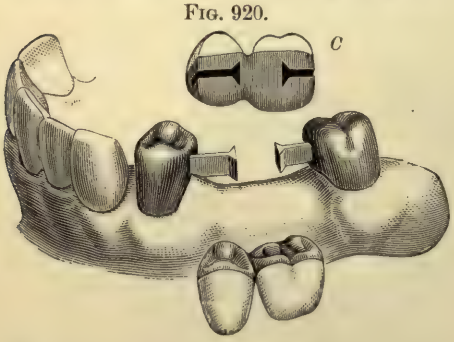


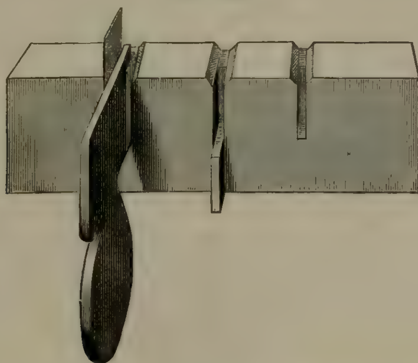
FIG. 921.

(Fig. 922). Sockets (2) of thin gold are made fitting these arms closely. The dummy crowns have had their caps fixed by solder to hold them in position. The sockets, with their ends projecting beyond the borders

[1] G. L. Curtis, *Cosmos*, vol. xxxii. p. 109 *et seq.*

of the dummies, are attached to the latter by means of fluxed wax. The pieces are invested, and the sockets are attached by means of solder, completing in this soldering the contour of the dummy block (*C*, Fig.

Fig. 922.

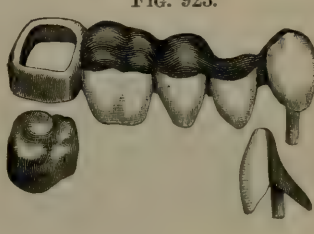


920). The surfaces of the dummies are cut away until the block fits closely between the crowns. The block is now smoothed and buffed. The arms are placed in their sockets, from which they project at their under surfaces. The palatal surface of the cast is varnished; the dummy block containing the arms is set in position: attach the block to the cast by a drop of adhesive wax melted at the junction of the porcelain with the cast. In the depression beneath the dummies pour soft investing material. When this has set remove the bridge, and a depression is seen in the investing material, in which the bar which made it is placed. Enough investment is added to hold the bars in position, which are to be perfectly united to the abutment crowns by means of solder.

These bridges are attached by cementing both crowns to their abutments with one mix of cement, and while this is still soft quickly setting the body of the bridge in position.

A variety of removable bridge, the design of which suggests it as one of wide application, is that of Dr. C. M. Richmond.[1] A model and zinc die are made of the abutment molar with its crown. Around this crown a telescoping collar is made, fitting it tightly: this is made of crown metal, about one-sixteenth of an inch longer than the crown. The die is driven into this collar, and the surplus length is swaged to overlap the occlusal surface of the crown. A second collar is adapted to the first and the two united with solder, forming a removable, rigid, and closely-adapted abutment piece. The other extremity of the bridge, its second abutment piece, is a removable post crown.

Fig. 923.



Dr. M. L. Rhein[2] has devised, applied, and furnished the models for

[1] *Cosmos*, vol. xxviii., No. 8, p. 497. [2] *Cosmos*, vol. xxxvi. p. 97.

one of the most ingenious forms of removable bridge yet presented. It is designed to overcome the several disadvantages incidental to the placing of a fixed bridge, to obviate the necessity for the occasionally great mutilation of abutment teeth, to enable the operator to apply a correctly fitting barrel, and to reproduce the slight movement possessed by the natural teeth in normal occlusion.

Fig. 924.

The distinguishing feature of the bridge (Fig. 924, 3) is the abutment crown made in such a manner as to fit closely the neck of a

Fig. 925.

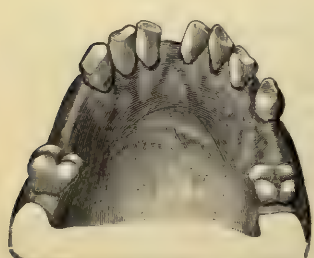
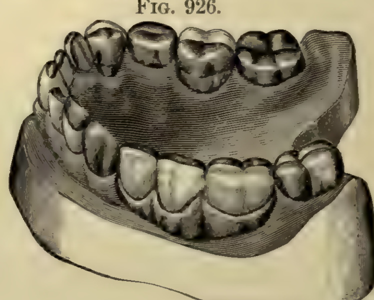


Fig. 926.



crown, smaller at this part than at its occlusal edge, without mutilating the walls of the crown. In constructing the crown an accurate plaster

impression of it is to be secured and a perfect model made in it. [The writer suggests the advisability of making this cast of one of the fusible alloys poured in the plaster impression.] The cast is trimmed away so that the band may go one-thirty-second of an inch beyond the gum line. The natural crown is shortened sufficiently to allow for the proper thickness of an articulating face on the crown after the impression has been taken. A piece of plate, 20-carat, 29 gauge, is swaged to cover the occlusal face and the walls of the crown to the swell of the tooth (*B*, Fig. 927).

A pattern is made of heavy foil. This may be done readily by bending a piece of tin to fit approximately the joint at the middle of the anterior face of the abutment crown: the ends of the pattern, left long, are grasped between the jaws of a pair of pliers and drawn tight against the walls of the crown: the edge of the tin is cut out to follow the gum outline closely, and again drawn tight by means of the pliers; the ends are left extending some three-sixteenths of an inch (*C*, Fig. 927). The

Fig. 927.

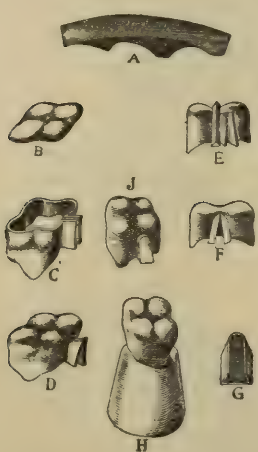
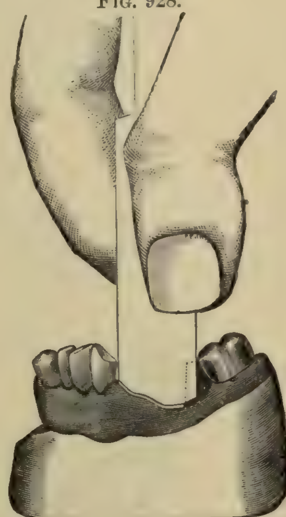


Fig. 928.

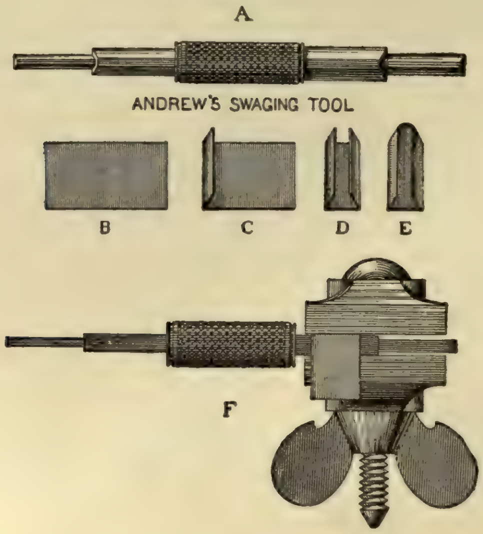


pattern is reproduced in 22-carat plate, gauge 30. A piece of pure gold is sweated to the free edge of the band, which is then closely adapted to the model tooth. A piece of mica is placed in the joint of the projecting tips, to prevent their union in soldering on the cap, which is adjusted in position and soldered to the band.

The shortest distance between the abutment crowns is marked on a piece of card-board, which is then squared to that width. Its edge, applied to the gum (Fig. 928), is cut to conform to the gum outline in a line which marks beneath the narrowest distance between the abutments. The second abutment crown is constructed and both are set in position on the model. The card-board is placed in position, resting upon the projecting ends of the collar ends, and the lines of its edges marked on these by means of a sharp blade. Pieces of perfectly triangular wire, half the width of the gib and longer than the crown itself, are cut, two

for each crown. One of these has an edge placed along the knife-mark and cemented into position by means of wax flux (Fig. 927, *E*).

Fig. 929.



A piece is placed on the second arm, exactly opposite and parallel with the first, and it is similarly attached. A thin shaving of mica is placed

Fig. 930.

between the projecting arms of the crown; the piece is invested, and the wires attached by the minimum of solder. The crowns are boiled in acid; the projecting ends of the wires are cut off, and the upper ends given a rounded bevel. The projecting ends of the crown arms are filed flush with the edges of the wires (Fig. 927, *F*). [The wires themselves are filed flat to present a common surface anteriorly.]

The key (Fig. 927, *G*) is formed of platinous gold in the following

manner: A piece of steel wire (triangular) is slightly flattened upon one side (*A*, Fig. 929). A small rectangle of platinous gold, 29 gauge, its short side wider than the length of the gib, is cut (Fig. 929, *B*), and on its surface the greatest width of the gib is marked. The plate is

Fig. 931.

bent over at one of these lines, placed in a vise, the short arm of plate against the wire, *F;* an arm is made, *C*. Turn the metal in the vise, and form the other side, *D*, the base of the piece measuring the extreme width of the gib. Saw-cuts, made at the angles to the depth of the bevel of the gib, will permit bending arms together and forming a cap to the key (*G*, Fig. 927): the joints are soldered and the key cut away until it is the length of the gib. The gib and key are accurately fitted to one another. The pieces adjusted in position, the crown is represented in *J* (Fig. 927). A second piece, similar to the key, is fitted over the latter to serve as the slot of the bridge.

The body of the bridge is formed with the slots attached, as described on p. 686. The abutment crowns are set by removing the keys, placing in the crowns sufficient zinc phosphate, and carrying them into position, when the keys are adjusted and forced fully into position, drawing the edges of the crowns into close apposition with the necks of the teeth. The pure gold edges are now burnished into perfect contact with the teeth. A bridge made and attached after this method is shown in Fig. 930.

Combinations of the Principles of Plate- with those of Bridge-work.

The principle involved in this class of mechanism was utilized early in the present century as a means of retention for partial dentures. There is a combination of the support represented in the bearing of a plate upon the alveolar ridge, together with the rigidity secured by having terminals or extensions from the plate anchored in the roots of teeth or embracing them as closed and rigid cylinders.

The principle of anchorage in the roots of a natural tooth is illustrated in Figs. 932 and 933; that of embracing the natural teeth by

closed cylinders, in Fig. 934; a combination of the two means of retention, in Fig. 935.

These devices possess certain advantages over clasp plates, in that there is no elasticity of the retaining cylinders: they slip over the abut-

Fig. 932.

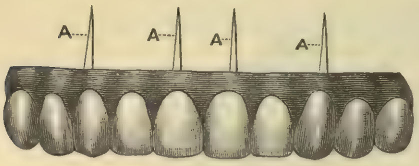


Fig. 933.

ments prepared for their reception, and, being closely adapted to them, there is a greater rigidity of the dentures than with the ordinary clasp.

For their employment it is obviously necessary that the abutments should have sides which are parallel and the axes of both mutually

Fig. 934.

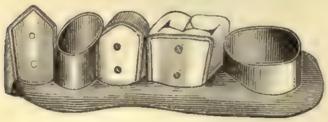
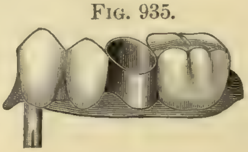


Fig. 935.



parallel. They are usually designed for application in cases where the natural teeth are in such positions and have forms which would fit them to serve as bridge abutments, but the contour of the gum is such that it is necessary to employ gum teeth (Fig. 936). They are, to all intents and purposes, removable bridges, having a greatly multiplied support from the natural gum.

It was stated (p. 671), in describing the bulkhead bridge, that should the contour of the gum be lost to such an extent as to preclude the application of a bridge, owing to the impossibility of correctly adapting plain teeth, a removable plate bridge might be employed. A removable bridge may be adapted to such a case as follows:

The cuspid roots are properly trimmed and capped. Removable crowns are fitted to them. A gold plate is swaged to fit the gum between the teeth, extending high enough on its labial aspect to furnish adequate support to the artificial gums, and the palatal edges far enough to furnish adequate support to the stays of the teeth. The plate is to be made of two layers—that next the natural gum of No. 32 pure gold, and covered by a plate of No. 32 platinous gold: the two are accurately adapted to one another and united by means of 20-carat solder. The ends are to be accurately adapted to the abutment crowns. Plate and crowns are set in position in the mouth, and a wax-bite taken: this is removed and set aside. While the pieces are in position an impression of modelling compound is taken. Modelling compound is preferred to plaster, because the pressure upon the plate forces the latter into accurate contact with the soft tissues. Should plaster be employed, a ridge of softened wax, wide enough to fit between the abutments, is set in the impression tray, and over it the plaster. Now, when the impression is

taken the plate is pressed up by the wax sufficiently to ensure that the natural gum shall furnish support to the finished bridge. A model is made and an articulation mounted. Should the plate be exposed by the movements of the lips, it may be necessary to adapt gum teeth (Fig. 936);

FIG. 936.

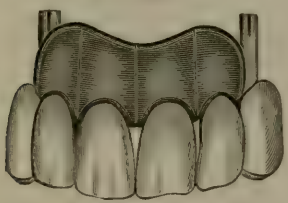
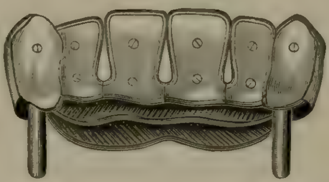


FIG. 937.



if not, plain teeth are fitted; the gum is to be subsequently formed of pink vulcanite. The teeth are to have stays fitted. The abutment crowns are removed from the model, and they, the teeth, and the plate boiled in acid. They are returned to the model and joined together by means of adhesive wax: a wire laid across the backs from one abutment crown to the other, and covered by adhesive wax, holds them in position. They are invested, and when the investment is set pieces of triangular wire are placed at the junction of the plate with the abutment crowns, and the pieces are attached to one another by means of 20-carat solder. If plain teeth have been employed, and, contouring is indicated, a vulcanite gum is attached to the plate.

Porcelain Bridge-work.

The general plan and methods followed in this class of bridge-work are those of Dr. E. Parmley Brown, who originated it.

The objections urged against bridge-work composed of fine gold and porcelain facings united by means of fine solders—that the spaces between the gum and the palatal surfaces of bridge were unclean; that the oxidation of the base metals of the solder permitted the accumulation of offensive materials; and that the porcelain facings were, through lack of bulk, in constant danger of fracture—led to the devising of this method, designed to overcome the several objections specified.

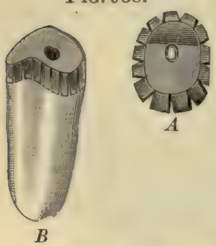
The bridge as made and recommended by Dr. Brown consists of a rigid supporting and anchoring bar, to which are adapted porcelain teeth, subsequently united to the bar and to one another by means of porcelain fused about the parts.

The usual method of anchoring the bridge is by means of arms extending from the ends of the bridge, which are anchored in cavities formed in the natural teeth for their reception. Instead of what are called "self-cleansing spaces," the base of the bridge presses firmly upon the natural gum, with a view to excluding even the secretions of the mouth. A base-plate of iridio-platinum may be accurately fitted to the gum, to which the porcelain of the bridge is to be attached.

A typical case for the application of this variety of bridge is that of the bulkhead—two cuspid roots supporting six artificial crowns. The abutment roots are prepared, a platinum cap fitted to each; the edges of

the caps are left projecting beyond the edges of the roots, then slit (Fig. 938, *A*)—bent over and adapted to the walls of the roots in the mouth (Fig. 938, *B*). The root-canals are enlarged and deepened, and metal posts filed to fit them are placed through openings made through the caps into the root-canals. A bite is taken; then an impression is obtained, in which the caps and wires are withdrawn. An articulating model is made, and facings selected and ground into position. The face of the model is varnished and oiled, and a plaster wall formed about the teeth and model, holding the former rigidly in position. A piece of annealed brass wire, three inches long, has one extremity filed to occupy the pulp-canal of a cuspid root to the depth it is designed to carry the anchoring bar; the wire above the cap is flattened to a distance which shall permit perforating it for the reception of the pins for the cuspid teeth. The wire is bent at right angles, then carried across the posterior surfaces of the incisor crowns; it is to occupy the space between the pins of these teeth. Above the upper pin of the opposite cuspid crown it is again bent at right angles; the lower end is shortened to adjustment with the depths of the pulp-canal. This wire forms a pattern which is reproduced in iridio-platinum wire from 13 to 15 gauge, which is annealed and flattened so that a portion of it will present a flat surface to the backs of the cuspids, and the transverse portion flattened to rest upon the backs of the incisors between the pins. The wire is bent to the conformation of the brass wire pattern (Fig. 939).

Fig. 938.



The caps over the root-faces are loosened, returned to position, and the iridium bar set in position. The wall holding the porcelain facings is applied, and the perpendicular arms of the flattened

Fig. 939.

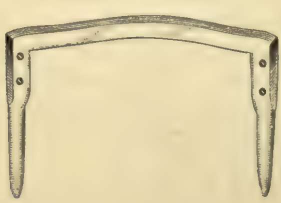
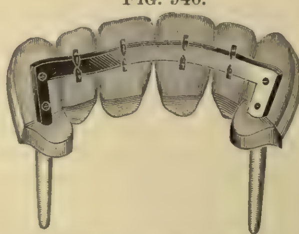


Fig. 940.



Porcelain metal band.

wire perforated for the passage of the pins of the cuspid crowns. The wall is removed, the bar is cemented to the caps, and these and the bar withdrawn from the model invested and soldered with the minimum of pure gold. The piece and teeth are boiled in a 1 : 3 sulphuric-acid solution. The bar and caps are set in position on the model. The teeth are returned to the plaster wall, the pins of the cuspid crowns passing through the perforations in the bar. The pins of the incisor crowns are bent over the bar, holding each tooth in position. The wire may be grooved or notched at the site of the pins to form retaining slots. The piece is now carefully lifted from the model and prepared for the application of the porcelain (Fig. 940).

Depressions are made in a fire-clay slab which shall support the bars and the teeth. Porcelain body, made into a paste with water, is applied, giving a contour in consonance with the articulation and the contact with the soft tissues. The body is applied as the second body of a continuous-gum piece. It is set on the supporting slab, and the porcelain fused in a proper furnace, as with continuous-gum pieces.

Gum contour of similar cases may be restored after the following method: Caps are fitted to the prepared cuspid roots as for the preceding case. A pair of cuspid facings are selected, and also four incisors of the continuous-gum variety. The cuspid caps are set in position and an impression in modelling compound taken, which presses firmly upon the anterior gum. A model of investing material, and next dies, are made, and an iridio-platinum plate No. 32 is swaged. This plate should extend upon the outer alveolar wall as high as it is desired to have the artificial gum. At its palatal aspect the edge should be formed to represent

Fig. 941.

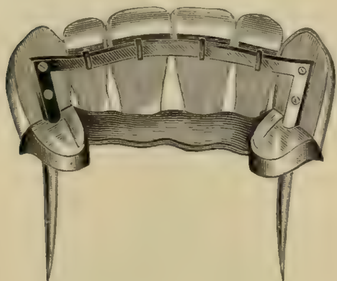
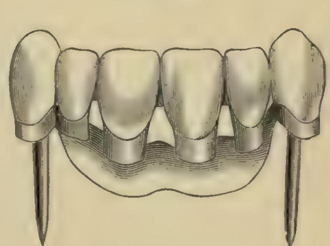


Fig. 942.



about the usual neck sections of natural incisors. The lateral edges of the plate should overlap or lie firmly against the sides of the cuspid collars, to which it is united by means of a small amount of 24-carat gold as solder. The piece is transferred to the mouth; wire posts the size of the canals are fitted; a bite and next a plaster impression are taken. A model of investing material is made and an articulator mounted.

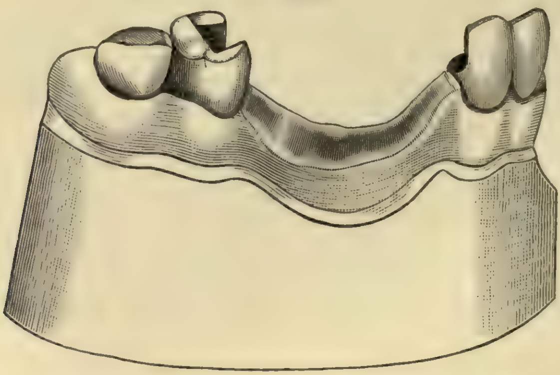
The porcelain teeth are now adjusted to position; the incisors, as though for the usual continuous-gum operations, and their stays are fitted to the teeth; a support and posts of the form previously described are adapted, over which the pins of the incisors crowns are bent (Fig. 941). More investing material is applied to cover and protect the porcelain, and the teeth are united to the bar and stays, and the posts to the collars by means of the minimum of 24-carat solder. Fig. 942 shows labial aspect. The porcelain is next added. Sufficient body is applied to give the desired contour, the piece is baked, and the gum enamel is then added and a final baking given.

Porcelain bridges for the replacement of the bicuspids and molars may be constructed after the same method.

Fig. 903 illustrates a typical case. A plate is swaged, being only of sufficient size to support the bases of the teeth and the artificial gum. When the plate abuts the natural teeth a surplus of metal is left. The teeth are adapted and the post and bar support formed. The teeth are

to have their stays adapted. The ends of the plate are burnished about the bar, and the pins are next bent down, holding the teeth in position

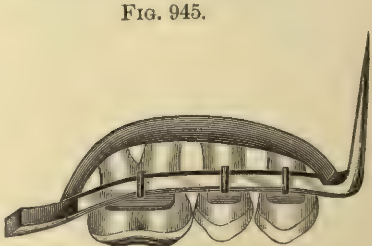
Fig. 943.



(Fig. 944). The piece is detached from the model, invested, and soldered by means of 24-carat plate. The porcelain is to be added as in the preceding case. Fig. 945 shows the finished case.

Fig. 944.

Fig. 945.



Figs. 946 and 947 illustrate the application of porcelain bridge-work to a common class of cases. A pulpless central incisor, which has not

Fig. 946.

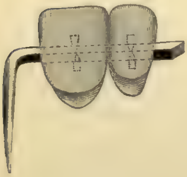


Fig. 947.

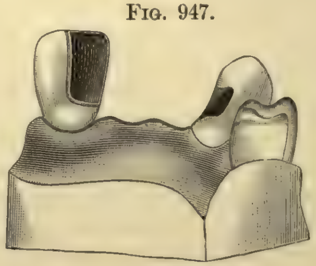
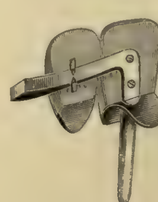


Fig. 948.



lost too much of its substance through the invasion of caries, and whose crown has not discolored, a cuspid which may contain a vital pulp or be pulpless,—these serve as the abutments. The anchorage in the cuspid, if it contain a vital pulp, should not be deep enough to endanger that organ, and yet should be sufficiently deep to ensure immobility of the bridge when anchored by a filling of cohesive gold.

Fig. 948 illustrates a bridge for a similar case, in which the crown of the central incisor is too frail to successfully resist the stress of mastication, or which has lost so much of its substance that decrowning is the indication for æsthetic considerations.

Setting Bridges.

Before cementing a bridge to its abutments it is tried to them, and, should any points interfere with its ready placement, they are cut or ground away until the piece may be slipped into position with easy facility. When the abutment crowns are of the barrel type, a minute opening is made in the sulcus of each crown.

The zinc phosphate used for bridge-setting should be moderately slow setting; it should remain plastic long enough to permit the deliberate and careful setting of the bridge; should flow freely even through almost microscopic openings; should harden in about fifteen minutes with a glazed surface; should quickly lose an acid reaction. In an hour it should be extremely hard, and it is of great importance that it should be but slightly soluble. Fresh specimens of bridge cement are to be tested to see that they answer these requirements.

For setting the variety of bridge mentioned, a few large drops of the cement fluid are placed on a clean mixing slab, and beside it an excess of powder. Powder is gradually and thoroughly incorporated with the fluid until a paste is made which drops reluctantly from the tip of the spatula. The paste, as it is, is carried into the deepest portions of the crowns. The abutment teeth, having been washed with chloroform to remove any fatty deposits and to dry them by its evaporation, are protected by napkins; the bridge is quickly carried into place and steadily pressed into its position. The napkin is removed and a piece of heavy tin-foil is laid over the entire masticating surface of the bridge, and the patient directed to close the teeth against it, and to keep them closed for twenty minutes. Patients should receive explicit injunctions not to masticate upon a bridge for at least two hours after it has been set.

In setting bridges, one or more of the abutment crowns of which are post crowns, the canals of the teeth should be cleansed with hydrogen peroxide and dried by means of alcohol and a hot blast. A wisp of cotton containing 25 per cent. pyrozone is passed around the neck of each root; this will prevent exudation and keep the root free from the contact of secretions until the collars are set in position. The cement is made slightly thinner for setting such crowns: the concavities of the crowns are filled with cement, a portion placed in the root-canal, and the bridge is carried into place when the occlusion is tested, the tin-foil between the teeth as before.

In setting a bridge, one abutment of which is a bar anchorage to have a metallic filling built around it, no attempt should be made toward making the filling until the cement about the other abutments is rigid. It is, however, a wise precaution to place a layer of amalgam upon the floor of the cavity before the bridge is adjusted, and then press the bar into the amalgam. A better practice is to line the cavity with filling material, shaping a cavity in it to engage the bar, and finishing the margins before setting the bridge. Then, when the cement of the other abutments has set, the filling about the bar is completed with

cohesive foil malleted about it, holding it firmly. When perfect dryness can be maintained rolled foil No. 30 is annealed and packed with a mallet.

In setting double-bar bridges the thinnest of rubber dam is adjusted, the cavities prepared, and the bridge set in position; the portions of the cavity which would be made inaccessible by placing the bars are filled as a preliminary measure—filled a little more than necessary; then slots cut in them which shall engage the edges of the bars, and the edges of the filling filed flush with the cavity margins. The bridge is set in position, and cohesive foil malleted about and over the bar, completing one filling. During the packing of the gold the bridge has been held rigidly in position with the left hand. If the veneer filling has been properly shaped, it almost retains the bridge of itself during the packing of the gold. The second filling is completed in the same manner, and both are trimmed and polished. The rubber dam is stretched, and a cut made, joining the openings embracing the abutment teeth, and is removed.

The Repair of Bridge-work.

The difficulty of properly repairing bridge-work is one of the objections persistently urged against it since its introduction. Any accidents to removable bridges are readily remedied by detaching the pieces and repairing in the same manner as the individual part was originally constructed. The common accident affecting fixed bridges is fracture of a porcelain facing. This occurs usually in consequence of the porcelain facings being improperly or insufficiently protected from the direct stress of mastication, and not infrequently by the tooth being split in one of the soldering operations. If the dummies and facings have been properly constructed, made from strong teeth, and due care exercised in soldering, porcelain facings should never break, as they are never subjected to stress.

To accurately replace a broken facing or to remedy any marked defect of a bridge piece, it is in the majority of cases necessary to remove it from its abutments. If the abutment crowns are of the barrel variety, it is usually necessary to split the barrels to effect their removal. By means of a fine hatchet excavator the crown is marked from its edge to its cutting surface by a gradually deepening groove made in its buccal wall. When the gold is cut through a fine instrument is passed into the cut and the cement detached piecemeal.

The crown may be quickly split by means of the cap crown-slitter (Fig. 949). An effort is now made to loosen and detach the bridge without splitting the second cap; if this is not possible, it is also divided at its buccal wall. Should one abutment crown be of the post-and-collar variety, a drill is passed through the palatal side of the cap, severing its attachment to the post. A square-edged instrument is passed above the edge of the collar, and traction in all directions is exerted until the bridge is detached. It may be necessary to divide the collar of this abutment also: this is done at the palatal side. Should it be the facing over a post crown that has broken, the division of the post from the cap may be made through the angle at the base of the stay; however, the perforation through the back should be made also for the introduction of the new post. The case is boiled in strong nitric acid, which will

dissolve the old cement and cleanse every crevice. The sections of the crowns are bent back into their original positions, and the post removed from the root, as described in Chapter XVIII.

Along the cuts of the crowns, in their interiors, small strips of thin platinum are attached by means of flux wax. The bridge is set in position in the mouth; a new post is passed into the root-canal of the anterior abutment through the opening in the cap made for its passage; the end of the post is to extend beyond the opening. A bite is taken if necessary, and an impression; a cast is made of investing material. A porcelain facing is fitted to the cap as described in Chapter XVIII. (Repairing Crowns).

A porcelain dummy to be replaced is adjusted in the following manner: A dummy the size and shape of the one broken is selected; a spear-pointed drill is passed through the backing and gold body in the positions of the pins; these openings are enlarged to easily receive the pins of the facing. A deep gutter is cut, burred away between the holes on the palatal side until the platinum pins protrude through them, when the facing is ground in. A thin layer of gold is scraped away from the backing, and the facing backed with very thin platinum. The surface of this stay and that of the gold with which it is in contact are covered with borax, and the facing set in position and held by means of adhesive wax melted over the ends of the pins.

The porcelain surfaces are covered with investment material, all the parts to be soldered left uncovered. The wax is removed, and the cast cut away to fully expose the gum edge of the platinum stay. A large piece of 14-carat solder is placed over each pin and a piece at the line of juncture between the platinum stay and the gold block, and over all

Fig. 949.

Cap-crown slitter.

other parts to be joined additional pieces are placed. The case is heated: a fine flame is directed against the investment, and when the porcelain is red hot a touch of the flame will fuse the solder over the line of division of the barrel crown. The investment quickly turned over, the flame directed against the solder at the base of the dummy stay will fuse the solder there and that placed over the pins; it will run through and fill the spaces between the parts. The soldering of the anterior abutment crown is next done.

This general method applies for all thorough repairs to bridge pieces.

The difficulty of removing bridges, the dangers of irremediable mutilation, and the necessary expense attending such a complicated repair have led to the devising of many methods for repairing while the bridge is in position without detaching it.

One of the methods is that of Dr. Mason, described in Chapter XVIII., where a removable porcelain facing has been used, anticipating possible fracture.

If a facing of one of the anterior teeth should be fractured, the pins are cut from the backing; a new facing corresponding with the old one is selected; its pins are to have their edges touched with a mixture of olive oil and vermilion, which marks the backings; holes are drilled through the backing by means of a spear-pointed drill, and are countersunk at their palatal sides. The tooth is to receive any grinding necessary to adapt it to the backing, and the pins are riveted in the following manner: One arm of a pair of plate punch-forceps is covered by a concave block of lead which rests upon the labial surface of the facing. The other jaw is armed with a broad punch, and between them the platinum pins are compressed into the countersinks, filling them and forming rivet heads. The heads are rounded by means of burnishers.

A method of replacing a molar or bicuspid facing is as follows: Holes are drilled through the backing, and at their palatal aspects are elongated divergingly. A facing is adapted to its surface and the pins covered with zinc phosphate, and it is pressed into position; the pins are immediately separated, being pressed against the far walls of the slots. When the cement has set any excess of pin or cement is removed.

Fig. 950.

Prof. E. T. Darby suggests a method which he has found to serve well: A cross-pin facing is selected. A slot is cut in the metal backing by means of burs, giving the cavity a pyramidal form, as in the Mason backing, its small end external. A metallic bar is soldered to the tips of the pins, which have been bent to diverge slightly, uniting them; the facing so prepared is cemented in the cavity made in the backing.

Dr. Emory A. Bryant[1] describes a novel and effective method of attaching a new facing. A tap and die the size of tooth-pins are necessary, together with a special countersinking tool and a screw-driver (Figs. 951 to 954). The pins are cut from the old backing, and holes are drilled the size of the pins of the new facing, and in the proper positions. With the countersinking tool held in a right-angled hand piece, the holes are countersunk exactly to the outer wall of the backing—no

[1] *Cosmos*, vol. xxxvi. p. 469 *et seq.*

more, no less. The nuts are made, or have been made, the size of the countersink. By means of the oiled die a thread is cut on the pin of each tooth, exercising great care that the pins are not twisted, the thread

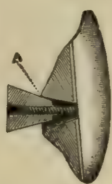
FIG. 951.

1

FIG. 952.

2

FIG. 953.



3

FIG. 954.

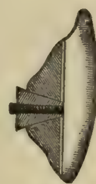


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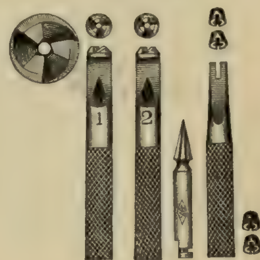
FIG. 955.



1 2 3 4 5

to be continued to the back of the facing. Nuts are tried on each of the threaded pins, and marked to denote the pins they fit. The facing is set in position, and each nut is loosely adjusted, then alternately screwed into place, drawing the facing close to the stay. The protruding portions of nut and pin are ground down and polished. Dr. Bryant states that this substitution may be made in twenty-five minutes.

CHAPTER XX.

HYGIENIC RELATIONS AND CARE OF ARTIFICIAL DENTURES.

By Charles J. Essig, M. D., D. D. S.

THERE can hardly be room for doubt that a well-planned and properly adjusted artificial denture contributes to comfort and health, and prolongs the life of the individual who by reason of premature loss of the natural teeth finds it necessary to wear one, but the usefulness of the fixture and its influence on the mind and general health of the patient depend very largely upon the manner in which it is planned and constructed. It may be made an instrument of discomfort, if not of torture, by constructing it upon a faulty impression. It may entirely fail to meet the demands of a masticating apparatus by imperfect articulation of the teeth. It may so interfere with speech, through want of adhesion, that the wearer is at all times conscious of its presence, and he is thus sometimes forced to give up social intercourse, or if, as in the case of lawyers or clergymen, professional duties require the individual to address audiences, the patient feels that his usefulness is abridged, and mental depression and departure from a normal standard of health follow.

Prosthetic dentistry requires in its successful practice good judgment, artistic taste, and a high degree of manipulative ability. No two cases are ever precisely alike, and each one demands careful study and a definite plan of procedure. The choice of material, means of attachment, style of teeth, and the arrangement of the latter to ensure the greatest attainable degree of efficiency in mastication are to be considered.

With the materials at the present time within the reach of every prosthetic dentist, and the light of the experience of other workers in that branch in the recent past, it is not claiming too much to say that artificial dentures may be so constructed and adjusted to any or all mouths as to restore the functions of mastication and speech, as well as natural appearance, in a manner but little short of absolute perfection.

The hygienic conditions incident to the use of artificial dentures may be local or systemic. Many morbid phenomena of a local character may be observed as resulting from their presence, and marked constitutional disturbances have been traced to the causes above alluded to, as well as those arising from long-maintained local irritation caused by maladaptation or the unsuitable character of the materials used in their construction.

In the insertion of an artificial denture a foreign body is introduced into the oral cavity which may act as an irritant to tissues and organs with which it comes in contact. This is particularly liable to occur in all lower dentures, on account of the pressure being confined to a narrower area and the muscles and integuments being attached well toward the top of the ridge, as in the case of the buccinator muscles; painful abrasions frequently result in this class of cases soon after the introduction of the fixture. Abrasions produced by undue pressure of the edge of a plate cause an amount of discomfort and suffering entirely out of proportion to the extent of the injury. To avoid a continuance of this trouble and to give immediate relief the patient should always be cautioned to return the moment the presence of the denture becomes painful.

Artificial dentures are held in place by atmospheric adhesion, by clasps, by spiral springs, or by permanent or immovable attachments to natural teeth or roots. Either of these may become the cause of irritation to the teeth or contiguous parts. In the case of clasps the tendency invariably is to produce morbid phenomena, and this tendency is increased or lessened by the character of the materials of which they are made, and the manner in which the clasps are adjusted and the parts of the teeth embraced by them.

The result produced by clasping natural teeth is a loss of tissues, either through caries, mechanical abrasion, electro-chemical action, or by the joint action of all three. The rapidity with which the disintegrating process advances depends largely upon the quality of the tooth-substance, the condition of the oral fluids, the size and form of the clasp, the portion of the tooth which is embraced by it, and the material of which the clasp is constructed.

A partial lower denture must be secured either by clasps or contact with natural teeth. In that class of partial lower dentures designed to replace the second bicuspids and molars on each side clasps adjusted to the first bicuspids are generally employed: caries of the approximate surfaces of the first bicuspids is more or less quickly induced, probably because the enamel is thin at that point. Incipient caries, produced by clasps at the positions above indicated, manifests itself by great sensitiveness of the tooth, which is exceedingly painful when exposed to extremes of temperature and certain kinds of food, such as very sweet or salt articles. Painful mechanical abrasions are frequently caused where mere contact with natural teeth is the means adopted for securing stability to partial dentures. Badly-fitting clasps, as may be expected, rapidly hasten the progress of caries by favoring the lodgement between the tooth and clasp of particles of food mixed with the oral fluids, which undergo fermentative decomposition and produce agents destructive to the enamel and dentine.

Clasps should be accurately fitted to the broadest part of the tooth, which is usually found at or near the masticating portion of the crown, and never at the necks of the tooth. They should not be allowed to impinge upon the gum, as recession of that tissue and exposure of the cementum, with subsequent softening and caries, will almost certainly supervene.

In addition to the liability to caries alluded to, the author has observed that when clasps are fitted to bicuspids for the purpose of re-

taining partial lower dentures *in situ*, those teeth are very liable to be loosened and speedily lost by the strain brought to bear upon them during mastication. For these reasons he has abandoned clasps in this class of cases wherever possible, using instead the outside bar shown on page 344.

The result of observation as to the effect of clasps upon the natural teeth is undoubtedly in all cases unfavorable, yet there are many instances in which clasps are indispensable ; but their capacity for doing harm may be very greatly reduced by adjusting them with accuracy to the most convex portions of the teeth, avoiding impingement upon the necks and cementum.

It has been observed that clasps exert an influence upon teeth varying in degree according to the condition of the oral fluids and the kind of metal of which they are made. Silver clasps have been found to exert a much more rapid disintegrating influence than those made of gold. Dentures with clasps or attachments made of platinum or iridio-platinum act more injuriously than the same appliances fitted with gold clasps. These differences in the effects of the metals upon the teeth are undoubtedly due to a galvanic current between the tooth-structure and the metal forming the plate, aided by certain conditions of the oral fluids.

Silver and platinum should not be used in the formation of clasps, or indeed for any purpose which demands contact with tooth-structure. It has been observed that platinum wire when employed as a means of retaining teeth, the positions of which had been changed in the correction of irregularities, showed erosions in a comparatively short time after its application.

An example of the action of silver upon the natural teeth was observed a number of years ago in the case of a man who had in an election fracas sustained a severe fracture of the jaw. When he presented himself for treatment at the college clinic, nearly a year after the injury had been received, it was found that the jaw was in three parts, no union having taken place. He had received a blow from some heavy instrument upon the mental portion of the bone ; the fractures were on each side between the first and second bicuspids. The individual, for some reason best known to himself, had been obliged to remain in concealment for several weeks after the injury, during which time he received no surgical treatment whatever. The appearance of the lower part of the face was greatly changed by the displacement of the disunited parts of the jaw, and mastication was impossible. As a temporary or palliative remedy for the latter difficulty a dental surgeon had fitted a bar of stout half-round silver wire entirely around the lower teeth, so as to hold the parts in juxtaposition and restore the articulation of the teeth. The individual had not worn the fixture many weeks before the posterior surfaces of the second molars, where the brunt of the force was borne, became unbearably sensitive. An examination showed deep grooves in these teeth, rapidly approaching the pulps. As the neighboring teeth appeared of good quality and entirely free of caries, the abrasion on the second molars was probably due to galvanic action between the silver support and the tooth-structure.

The wearing of artificial dentures at night is a subject upon which there is much difference of opinion : there is hardly room for doubt,

however, that disintegration of the tooth-substance when clasps are used is likely to proceed much more rapidly where the piece is worn continuously; besides, careful observation has shown that at night the oral secretions assume a slightly acid character. This has been demonstrated particularly in patients subject to enamel erosion by carefully testing the oral secretions with litmus after waking and before the salivary fluids have started their usual flow.

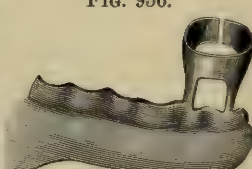
If the necks of the teeth are highly sensitive or there is well-marked tendency to softening or erosion of the tooth-structure, the patient should be directed to remove the plate each night before retiring, and to apply to the affected teeth, after thoroughly cleansing, a small quantity of precipitated chalk, lime-water, or milk of magnesia.

Too much stress cannot be laid upon the necessity for cleanliness, and every patient who wears a denture secured by clasps should be particularly instructed in the means of removing the deposits which are usually found on the inside surfaces of the clasps. This is not generally well done by patients with the tooth-brush alone, so that a piece of soft wood armed with fine pumice is necessary to do it thoroughly, and the addition of aqua ammonia is efficacious.

Patients suffering from any chronic conditions of the system which are likely to be accompanied with acidity of the oral fluids must be cautioned to exercise the most scrupulous care in cleansing the artificial denture; and this caution is particularly demanded when partial dentures are worn. In these cases lime-water and bicarbonate of sodium are recommended as alkaline mouth-washes, which by neutralizing the acid condition of the fluids are often effective in preventing sensitiveness and the tendency to softening of the tooth-substance.

In attaching clasps to the elongated molar teeth of elderly patients the clasps should be arranged so that no broad metallic surface will be in contact with the exposed neck of the tooth. This may be accomplished by attaching the clasp to the plate by two narrow posts, as shown in Fig. 956.

FIG. 956.



In the mouths of young persons whose teeth show unmistakable evidences of a tendency to rapid decalcification clasps should never be employed; and this is a matter to be decided by the dentist himself even when the patient expresses the strongest preference for the small plate attached by clasps and an equally forcible objection to the larger atmospheric plate.

Of the hygienic relations of spiral springs, which as a means of retaining artificial dentures antedated all other devices now in use, very little need be said, since the appliances are no longer used except in rare cases of edentulous mouths complicated with cleft palate, wherein atmospheric adhesion would be impossible. Three principal objections may be urged against the employment of spiral springs for the retention of ordinary dentures, as follows: their liability to chafe and abrade the delicate mucous-membrane lining of the cheek, the tendency of one or the other to break, and the difficulty of thoroughly cleaning them.

The materials used in the construction of artificial dentures, other conditions being equal, do not differ to any great extent in their effect

upon the tissues with which they come in contact. On the other hand, the frequency and extent of oral irritation associated with the wearing of artificial dentures, irrespective of materials employed, varies with different individuals. It is not, however, denied that modifications of that portion of the surface of the mouth covered by the artificial denture is more frequent in cases where rubber and celluloid are worn. The author has always believed that the real cause of the inflammatory condition so generally attributed to vegetable bases will be found in the following conditions: (1) The non-conducting quality of the substances; (2) the rough condition of the surfaces of the majority of rubber or celluloid dentures, due to carelessness or want of skill in construction; (3) want of care on the part of the wearer in not frequently cleansing the denture of deposits of food and secretions of the mouth, which are likely to undergo chemical change by long confinement in contact with the tissues, and thus become irritants. Either one or all of the conditions named may cause inflammation of the mucous membrane, but always, so far as the author's observation has gone, limited to the area covered by the plate. Similar conditions are frequently noticed when the dentures were of gold or silver, but always in cases where the plate was seldom removed or cleansed. And if the trouble referred to is more common in rubber or celluloid dentures than where metallic plates are worn, there are doubtless more conditions favoring such a result in the former than are found in the latter; and the facts that the symptoms are not constant, and that by far the greater number of mouths in which rubber or celluloid is worn are not in the least affected by it, would seem to confirm the view that the inflammation referred to is due to contact with irritating products of food and secretions, and that these are equally active in all dentures, irrespective of the material of which the denture are made.

Rubber sore mouth as described in the *American System of Dentistry,* if met with at all, must be exceedingly rare, and the "rubber sore mouth" which passes the stage of redness and slight tenderness and extends to the tonsils and walls of the pharynx, with the parts greatly swollen and painful, rendering the wearing of the plate impossible for the time and the formation of abscesses, the author has never seen.

Acute inflammatory conditions of the mouth which appear with some degree of suddenness may often be traced to persistent efforts on the part of the patient to obtain atmospheric adhesion in a badly-fitting denture by powerful suction of the tongue in the effort to exhaust the air from the chamber: violence of this kind, aided by the other unfavorable conditions referred to, may cause occlusion of mucous follicles and the usual inflammation resulting from interruption of the secretions; but it would be manifestly wrong to class such conditions under the heading of "Rubber Sore Mouth."

The great majority of cases of local irritation associated with the wearing of dentures are not usually cases calling for the exhibition of drugs, but as the rules of hygiene extend to all conditions which may cause departure from a normal standard of health, whether local or general, the first step in the treatment of so-called "rubber sore mouth" should be an examination of the plate to determine—1st, if there is accuracy of adaptation; 2d, is the surface of denture smooth enough, and in proper condition to be constantly worn in contact with the delicate

tissues of the mouth? 3d, is the denture free of deposits of food and secretions? A cure will usually be promptly effected by the fulfilment of the three conditions named.

Rubber dentures favor the deposition of material composed of food and mucus secreted from the follicles of the tissues covered by the plate, which often escapes the observation of the patient and is always difficult to remove thoroughly. The patient should be carefully instructed as to the best means of keeping the denture free from this deposit, which will consist in the frequent use of a strong solution of soda, in which the plate should occasionally remain immersed over night, and when the deposit is thoroughly softened by the soda solution the careful use of the tooth-brush armed with soap and tooth-powder. Salivary calculus, which often deposits in large quantities on lower plates, may be removed by immersing the denture over night in vinegar and water; but if crowns of natural teeth have been reset on metallic plates, the salivary calculus must be removed by instruments, as any form of acid would dissolve the enamel and ruin the teeth.

If a chronic state of inflammation of the surface covered by the denture has become established by violation of the conditions essential to maintenance of a normal state of the oral tissue, local applications of phénol sodique, thymozone, or listerine, diluted in the proportion of one part of the remedy to three or four of water, will generally relieve the tissues of redness and tenderness.

In cases of long standing and unusual severity zinci sulphas in solution, in the strength of gr. j or ij to f℥ss of water, will be found of great service as an application to the inflamed parts.

Some authorities state that chronic stages of so-called "rubber sore mouth" are curable only by the substitution of a denture made upon metal. Such cases the author has never met with, and he believes that careful fulfilment of the conditions of precision of adaptation, smoothness of surface in contact with the tissues, and absolute cleanliness will generally be found sufficient to restore the mouth to a normal state.

Excessive absorption of the alveolar ridge, ending in the entire obliteration of any semblance of a ridge, is extremely rare, and not a single instance of the kind has been met with by the author in his entire practice. The few cases of absorption of the anterior portion of the ridge which have come under his notice have been mouths in which metal plates have been worn. This phenomenon has been attributed to the poisonous action of vermilion used in dental rubbers as a pigment; imperfect vulcanization, causing porosity of the plate, thus favoring the absorption of secretions or the growth of micro-organisms on that portion of the plate in contact with the mucous membrane; but it is quite probable that excessive absorption of the alveolar ridge is an inherited tendency. The author has observed that condition in more than one member of the same family, and he has very recently made dentures for a gentleman of advanced age and his daughter, in both of whose mouths the anterior portion of the alveolar ridge has quite disappeared, while the ridge in the posterior part of both mouths is unusually broad and prominent.

Pure vermilion, in combination with rubber, is not likely to produce deleterious effects when worn in the mouth, nor is it probable that this

compound can be decomposed chemically and converted into a poisonous salt of mercury by mere contact with the saliva.

The mechanical dentist will, however, do well to avoid the use of nitrohydrochloric acid in removing tin-foil from the surface of unfinished vulcanite dentures. (See chapter on Metallurgy: Mercury.)

Regarding the presence of free mercury in rubber before or after vulcanizing, Prof. Austin stated that the researches of Prof. Johnston with the microscope, and of Prof. Mayer by chemical analysis, failed to discover the slightest trace in samples of that which had been used for several years. Prof. Wildman observed that sulphur sublimed during vulcanization, but did not find the smallest trace of free mercury. Prof. Austin further stated that he never during his entire experience with indurated rubber as a base for artificial dentures detected the slightest particle of metallic mercury on the surface of any finished piece.

In the belief that mercuric sulphide (vermilion) may be the cause of the different phases of so-called rubber sore mouth, the substitution of black for red rubber has been recommended as a means of overcoming the tendency to excessive tenderness of the mucous membrane covered by the plate. Black rubber is but a doubtful improvement upon the red variety so far as influence on the health of the tissues is concerned. As it contains lampblack as a pigment, it is uncertain whether it is more dense and less liable to absorb secretions. The best quality of rubber for dental purposes, the one affording the greater density of surface, is that which is composed simply of caoutchouc 48 parts, sulphur 24 parts, without any pigment whatever. This rubber is of a dark drab color, and it differs so widely from the color of the tissues that it has never been employed to any great extent in prosthetic dentistry.

Vulcanizable rubbers, of whatever composition, require great care both in investing and indurating. Campbell, the inventor of the "New Mode Heater for Rubber and Celluloid Work," demonstrated that the only way to obtain fine texture and density of surface in rubber and celluloid is to expose them to low temperature, dry heat, and contact with metallic surfaces.[1] This produces a harder rubber, less porous and less liable to absorb the secretions than can be obtained by contact with plaster, or indeed by any other means; but where the modus operandi suggested by Drs. Campbell and Evans is practised the preliminary "waxing" of the case must be done with such precision that the surface thus obtained need not be subsequently disturbed by the scraper. (See chapter on Vulcanite and Celluloid Work.)

The theory presented by Dr. G. V. Black, that the sore mouth produced by artificial dentures is due to the growth of certain fungi which elaborate an acid secretion which acts as an irritant to the mucous membrane, is probably correct. He asserted that he found these fungi upon the surfaces of all plates without regard to the material of which they were constructed, but in the greatest number upon the surfaces of vulcanite dentures; which he attributed to the fact that the irregularities and roughnesses of the surfaces of such plates afforded lodging-places where they rapidly developed on account of the greater difficulty in

[1] The manufacturers of rubber articles of jewelry and ornamentation long since abandoned the use of steam as a heating medium and plaster as an investment.

thoroughly cleansing them, and he regards absolute cleanliness as a complete protection from inflammation.

Prof. E. C. Kirk stated, as the result of repeated tests of the mucous secretion in cases of sore mouth associated with the rubber denture, that the mucus in such cases generally showed an alkaline reaction as it was eliminated; and he suggests the possibility that alkaline sulphides might be eliminated to a sufficient extent to exert a slight solvent action upon the mercuric sulphide of the plate, and thus form an active salt of mercury. But this theory seems to be at variance with the more practical reasoning and experience of many others who have given much thought and attention to the subject. Prof. Kirk's suggestion, however, that the non-conducting quality of the vegetable bases plays an important part in the production of every kind of inflammatory action undoubtedly carries with it much force, for, as he states, "the effect on the tissues continually enclosed by the non-conducting plate is to maintain a hyperæmic condition, with slight increase of temperature: this in addition to the pressure, which, if it does not result in inflammation, is a source of irritation sufficient to bring about greatly increased functional activity of the cells of the parts."

It was at one time thought, and so claimed by many of its advocates, that the substitution of celluloid for rubber dentures would prove an effective remedy in cases of sore mouth; but that material is open to the same objections as rubber, and to a greater degree in consequence of the sponginess of surface incident to the evaporation of camphor.

Partial artificial dentures immovably attached to one or more natural teeth or roots of teeth, or the attachment of several crowns to one or more roots as in bridge-work, present many points for consideration from a hygienic standpoint. The operation of substituting an artificial crown for a natural one should not, if properly performed, affect the integrity of any of the surrounding tissues, and yet if the work is ill-fitting and done in a slovenly manner, with the cap or ferrule extending so far under the free margin of the gum as to impinge upon the alveolar border of the socket, persistent irritation may be established, which can only end in disorganization of connective tissue and loss of the root if the cause be not removed. The experience of the author has been that roots upon which artificial crowns have been fixed are less liable to pericemental inflammation and abscess than are devitalized teeth with natural crowns, the greater success in the treatment of the crownless root being probably due to its accessibility and the better opportunity which undoubtedly exists of filling the latter with thoroughness to the full extent of the canal.

The fact, too, of restoring occlusion, whereby roots are brought into use, helps to keep them in a healthy condition, and prevents their gradual extrusion and premature loss from the alveoli.

As is well known, there are a variety of methods of setting artificial crowns to roots. Any one of these methods, if lacking in the element of precision of adjustment, may favor the establishment of pathological conditions. The Richmond crown, properly so called, with an accurately fitted cup or ferrule, is perhaps less liable to cause irritation to the surrounding tissues than any of the methods of crown-setting in use.

The worst results have been noticed in that class of crowns, without

caps or ferrules, in which the attachment to the root is secured by means of amalgam. If the latter is allowed to project at the point of union of the crown and root, it soon becomes exceedingly irritating to the margins of the gum—a condition marked by redness, tumefaction, and a tendency to bleed, particularly in the recumbent position at night, and a nocturnal flow of saliva similar to that noticed in pyorrhœa alveolaris becomes established. The only remedy for chronic dental irritation due to this cause is the removal of the crowns and the substitution of others which are not dependent upon amalgam as a means of attachment.

Bridge-work, which consists of the bridging of interdental spaces by one or more crowns fastened together and attached to natural teeth or roots, frequently causes pathological conditions from a want of care and exactness in their construction, and by requiring two or more roots to sustain an amount of force in mastication greatly in excess of that for which they were intended. As a result of the excessive strain to which they are subjected under such conditions, fracture of the roots, chronic inflammation of their pericemental membranes, abscesses, or protracted tenderness may occur, either of these being sufficient to seriously interfere with mastication and render the denture useless.

Cases of serious local irritation from unusual causes are occasionally met with in so-called bridge-work. The author recently met with a case in which a bridge had been constructed for the purpose of replacing two right superior bicuspids. The attachment consisted of a wire of ordinary 18-carat gold fastened with amalgam in the cuspid and first molar, both of which were devitalized. The wire had gradually yielded under the pressure of mastication until the necks of the two artificial teeth had become imbedded in the gum tissues, which were so much swollen that only the points of the porcelain teeth were visible. The general health of the patient was greatly affected by the persistent irritation caused by the displaced bridge: no time was therefore lost in removing it. This was done with the greatest relief to the patient, the tissues returning within a few days to their normal condition.

Although skilful and experienced bridge-workers generally plan and construct dentures of this class with special reference to complete cleanliness, yet it is doubtful whether all parts of the best of them can be reached by the tooth-brush as thoroughly as is the case with the ordinary removable denture. In many cases the irritation induced by the impaction of food-débris and fermenting secretions, and the unusual strain upon roots of diseased teeth, will cause hypertrophy of the surrounding tissues or rapid loosening from absorption of their alveolar borders. These conditions are always accompanied by more or less vitiation of the secretions of the mouth and foulness of breath, constituting in many cases potent arguments against their introduction.

Of the different methods of constructing this class of dentures, the removable bridge introduced and described by Dr. C. M. Richmond is probably open to fewer objections than any of the other forms; yet even that plan requires good judgment in determining the capability of teeth or roots to sustain the extraordinary strain to which they must necessarily be subjected, and the greatest skill and care in the construction and adjustment of the different parts of the fixture.

The introduction of immovable "bridge" dentures has undoubtedly

in a great many cases caused so much discomfort and irritation to surrounding tissues as to render mastication almost impossible, and it is doubtful whether extensive operations of this class, considered from their hygienic relations, are as satisfactory as properly planned and constructed removable dentures retained in position by atmospheric adhesion.

Care in cleansing artificial dentures of whatever form, size, or material is of the utmost importance. The cleansing should be performed immediately after eating, and particularly before retiring for the night. If this be not done with some degree of thoroughness, débris of food mixed with saliva and mucus forms an adherent mass upon the plate which undergoes fermentation and decomposition, with the result of irritating the mucous membrane and producing a general inflammation of the oral cavity, and the irritation of the oral secretions may cause serious derangement of the digestive function.

It is the duty of the dentist to instruct his patient as to the importance of cleanliness and in the proper means by which that result may be accomplished. The thorough cleansing of an artificial denture, although apparently a simple operation, seems to be a matter of great difficulty to the majority of patients, and but few are capable of maintaining a faultless condition of their dentures; yet the tooth-brush armed with soap and ordinary tooth-powder is quite sufficient to maintain a clean and highly polished surface. The patient should be cautioned against the danger of bending partial lower dentures of gold or other metals by grasping them with too much force while brushing, and in the case of vulcanite dentures to avoid "boiling them out" in hot water. Many individuals who have previously worn gold dentures resort to that means of ridding the fixture of deposits of food, etc. which have found a lodgement under the teeth and behind the backing. The author has met with several instances where recently constructed vulcanite dentures have been completely ruined within a short time of their completion by immersion in boiling water.

In the construction of metallic plates for partial dentures the plate should be accurately fitted around remaining natural teeth, so that there will be no spaces between the plate and the teeth to admit of pinching of the gum between the edge of the former and the neck of the tooth; and where a point of the plate extends between two teeth—as, for instance, the central incisors—such projection must be made to fit the space accurately, or it will be certain to cause inflammation which may result in permanent impairment of the teeth. Defects of this kind may be corrected by soldering an addition to the edge of the plate in order to bring it almost in contact with the teeth, or else by cutting away the plate so freely that its distance from the teeth will preclude the danger of pinching the tissues.

CHAPTER XXI.

PALATAL MECHANISM.

By Rodrigues Ottolengui, M. D. S.[1]

Cleft Palate.

Cleft palate may be divided into two classes — acquired and congenital. Acquired lesions include all of those cases where the individual, having been born with a normal oral cavity, later in life suffers

Fig. 957.

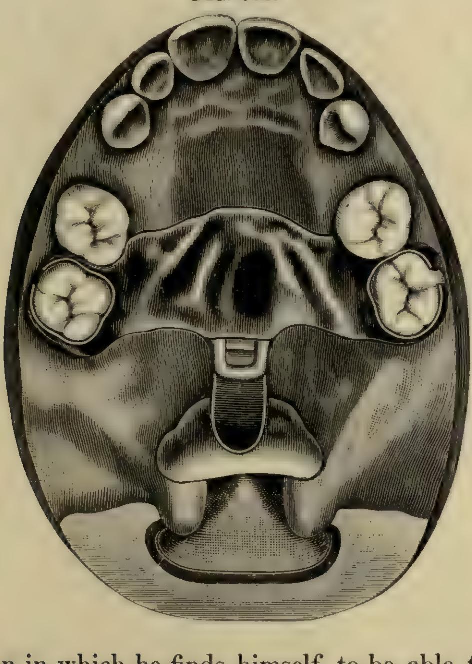
a division of the hard, or of the soft palate, or of both. This unfortunate mischance may be caused by an accident, such as a knife-thrust; the sequence of disease, usually syphilis; or the result of a surgical operation for the removal of malignant growths.

[1] I am indebted to Dr. Norman W. Kingsley for the use of his large collection of models from which to choose for illustrations, as well as for the privilege of referring to cases from his practice in order to more clearly expound the theories and principles set forth.

The acquired lesions may be very slight, as a mere perforation of the hard palate, or they may be most extensive in character, comprising a complete cleft of the hard and soft palate, with total destruction of the vomer and turbinated bones, as well as the bridge of the nose, and sometimes the nose itself. Such an extreme case, of course, would only have its origin in disease. Between the two extremes cited an endless variety of cases are found, many of which will tax the ingenuity of the operator to its utmost. The conditions which may follow upon unsuccessful surgical operations frequently add to the complexities of cases. Fig. 957 shows such a case, the absence of the uvulæ, and the adhesions which have united the posterior borders of the divided soft palate to the pharyngeal wall, making this case readily distinguishable from one of congenital origin.

Nevertheless, whether the acquired lesion be of small or great extent, the prognosis is more certain than in the congenital cases, because it has been demonstrated that if the operator succeeds in replacing the lost parts with an instrument properly constructed and suited to the individual requirements, normal functions will be restored almost immediately. The patient needs but to accustom himself to the new and

Fig. 958.



strange condition in which he finds himself, to be able to speak as well as ever; this because he had acquired all the normal habits of articulate speech before meeting with disaster. He has lost part of the natural organs with which he was endowed, but, having known their uses, he readily accustoms himself to the artificial substitute, which enables him to produce the same sounds by the same movements of the organs which remain intact. As the instruments to be made for persons

suffering from such misfortune are to be constructed on the same general principles which must guide the dentist in the treatment of congenital lesions, description at this point is unnecessary.

Congenital cleft palate is a division of the roof of the mouth of more or less extent, which is present in the infant at the time of birth.

Congenital clefts come to the dentist for treatment in one of three conditions: The cleft of the soft palate only, which may extend to the posterior border of the hard palate or be scarcely more than the division of the uvula, as in Fig. 958; the cleft of the soft and hard palate, in which the cleft may penetrate the bony tissue but slightly or pass through the hard palate and also the dental process, obliterating entirely the intermaxillary bones, as in Fig. 959: any of the above con-

Fig. 959.

ditions complicated in an endless variety of ways through unsuccessful surgical operations. In these latter cases the most common presentment is a bridging of the gap, with the soft tissues drawn together tensely, leaving an aperture through the hard palate anteriorly and an inadequate length of soft palate posteriorly, the tightly drawn tissues which form the surgical bridge not being long enough to occlude with the posterior pharyngeal wall; or where there has been only a cleft in the soft palate, the cleft is usually found partially closed, with no advantage to the patient, and offering a greater obstacle to the success of the dentist.

In some of these cases the intervention of the dentist is rendered useless, while in those where it is possible to make an instrument, the

difficulty of constructing the same is greatly increased, owing to the complexities of the altered conditions.

The modern instrument which the skilled dentist supplies to a cleft-palate patient, is either an artificial velum or an obturator, both of which are admirably adapted to the correction of the abnormal speech of these sufferers, and either of which may be requisite in a special case. It may be stated, however, as a rule for guidance in general practice, that *the artificial velum will more quickly enable a cleft-palate patient to acquire the art of speaking correctly*, whilst after having *learned* to speak properly the obturator may afford him equal satisfaction.

The above statement is an important truth which should be prominently borne in mind; and, moreover, it is this fact which accounts for the many recorded cases where dentists have replaced artificial vela with obturators, often poorly constructed, and then have hastily published the statement that the patient liked his instrument so much better than the other, and that "she talked perfectly as soon as my obturator was inserted." In making obturators for persons who have never worn an instrument of any kind their results would be much less favorable.

The knowledge of how best to serve a cleft-palate patient, and what manner of instrument is best adapted to his requirements, necessitates an intelligent comprehension of his needs, as well as of the principles upon which obturators and vela are constructed, together with the uses which they are meant to serve.

In the production of articulate sounds the normal individual is supplied with a soft palate, or natural velum, of great mobility, suspended from the posterior border of the hard palate. This natural velum serves two important purposes: First, it is needful, in the production of many sounds, that they should be free from nasal resonance, which would result if permitted to escape through the nasal passages. That the nasal and oral cavities may be completely separated, the posterior wall of the pharynx rises, forming a well-defined ridge, against which the velum occludes, being drawn backward and upward to meet it. Thus the sound is forced to pass exclusively through the mouth, and is rendered clear and distinct. Second, the natural soft palate serves as an abutment against which the tongue rises in the formation of such sounds as *k*, *g*, and *ng*.

A cleft of the palate consequently leaves the patient with no means of shutting off the nasal passages, and with an inadequate organ with which to produce the sounds specified as well as many others.

The artificial palate, therefore, whether velum or obturator, must enable the patient to completely shut off the nasal passages, and it must stop the gap in the roof of the mouth, restoring the normal vault, and rendering possible the production of all the sounds with which the cleft interfered. The artificial velum and the obturator both accomplish this, but their modes of action are quite distinct.

The artificial velum which has proven to be the simplest and at the same time the most universally efficacious is the invention of Dr. Norman W. Kingsley. It is made of soft rubber (vulcanite), from which fact it is clear that the theory of its action is to simulate the movement of the natural organ which it replaces. Being exceedingly mobile, it responds to the movements of the muscles which it engages, rising and falling

exactly as a natural velum would, while it is so fashioned that at the same time it occludes with the ridge of the pharyngeal wall, completely shutting off the upper passages.

The Kingsley velum (Figs. 960–962) consists of two flaps joined throughout the median line. The lower flap, the one which completes

FIG. 960.

FIG. 961.

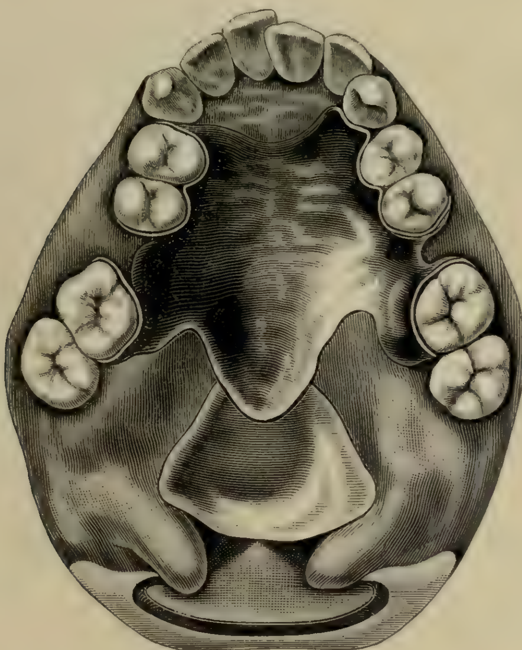
FIG. 962.

the palatal dome, extends from the apex of the fissure posteriorly as far as the bases of the uvulæ. Its general form is that of a triangle, the apex of which occludes with the apex of the cleft, the base extending across from one uvula to the other. This flap overlaps the soft parts sufficiently to prevent its being pushed through the cleft into the upper cavity. The other flap is of a similar triangular shape, the posterior border, however, being curved and thinned out to a feather edge, so that when in occlusion with the pharyngeal wall it curls up, thus presenting a flat surface for better contact, while its thinness prevents irritation to these sensitive parts. This flap is above the fissure and rests upon the upper surfaces of the divided palate. The two flaps are united along the median line, so that when complete they form a single appliance. The flaps having but a narrow line of union, grooves are produced laterally, and when in position the two halves of the soft palate rest in these grooves.

In connection with the artificial velum a metal plate is constructed, clasped to the teeth, having a pin upon the upper surface which passes

through a hole in the velum, and thus holds it in place while allowing it lateral motion. Fig. 963 shows an instrument in position, the uvulæ appearing pendant below the grooves of the artificial palate. Note the relation between the posterior border of the velum and the wall of the

FIG. 963.



pharynx. The *rationale* of this appliance is as follows: In the effort to close off the upper passages the sides of the divided natural palate approximate each other, and at the same time are drawn upward. Thus they first hug the artificial velum tightly, and then, owing to its elasticity, carry it upward. Coincidently, the wall of the pharynx rises, forming a ridge which meets the feather edge of the artificial velum,

FIG. 964.

curling it up, thus accomplishing perfect contact, completely preventing the escape of sounds through the nasal passages. At the same time the velum, completing the proper arch of the vault, is rigid enough to serve as an efficient abutment for the tongue when necessity compels such con-

tact. Fig. 908 shows the upper view of the instrument seen in Fig. 963, and is introduced to give a clearer idea of the attachment of the velum to the plate, as well as the general character of the grooves.

As stated above, the flaps which constitute the velum are triangular in shape, yet it will be observed that the velum shown in Fig. 962 is square at the anterior end. Where the cleft is in the soft palate only the triangular velum is required, but where the cleft passes forward, entering the hard palate, it is frequently more desirable to fill the aperture in the hard palate by vulcanizing hard rubber upon the upper side of the metal plate, the soft-rubber velum having a square end to meet a similar surface of the hard rubber.

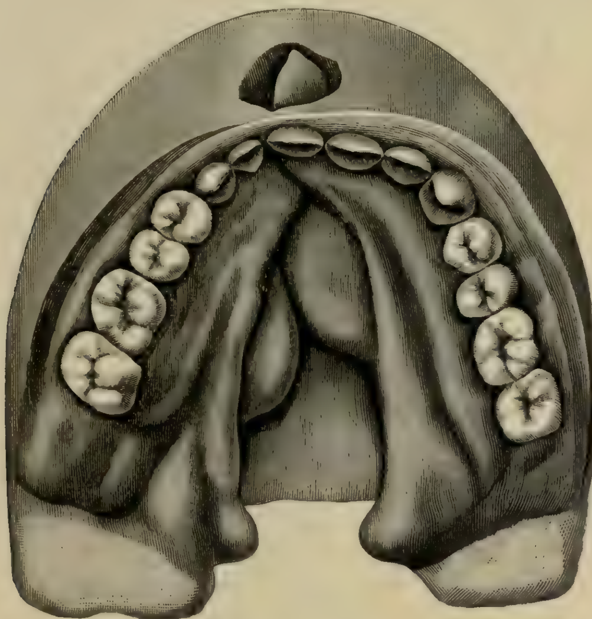
Such an instrument is seen in Fig. 965, the abutment of the hard and soft rubber being clearly indicated. The projecting point seen in this

Fig. 965.

figure was for a special purpose, and is not ordinarily required. This patient was a girl aged fourteen, and presented an extensive fissure through hard and soft palate, complicated with a hare-lip, upon which a fairly good result had been obtained by a surgical operation in early life. Fig. 966 shows a model of her mouth, the aperture seen above the incisors representing the passage of the fissure through to the nose, but somewhat exaggerated, having been enlarged with a knife for convenience in constructing the instrument. The girl's articulation was bad, but the greatest difficulty of understanding her arose from the excessive nasal quality of her voice. Externally, she was much disfigured by the fact that the ala of the nose, on the side where the hare-lip had been, was more sunken than is usual—so much so, indeed, that the nostril on that side was completely closed. If the reader will read aloud a few lines on this page, and while doing so will close one nostril by pressing down the ala with one finger, he will readily discover that such closure of the nostril produces considerable nasal quality of voice. Thus it was very desirable, both from a cosmetic standpoint and for the benefit of her speech, that the sunken ala should be raised. Indeed, the father of the child earnestly solicited an attempt of this nature. Thereupon the writer adopted what proved to be a simple and effectual method of accomplish-

ing the desired end. The metal plate having been fitted, a square platinum bar was soldered to the upper side and bent so that it protruded through the nostril, when it was cut off short enough to be out of sight. The hard rubber intended to plug the aperture in the hard palate was then

Fig. 966.



attached, and with the soft-rubber velum in position the result is seen in Fig. 965, the end of the platinum bar being shown at *a*. The next step was to make a square tube which should telescope over the platinum bar, fitting accurately, so that motion would be prevented. To the end of this tube was soldered a platinum button, so placed that when in position it rested against the inner surface of the sunken ala and lifted it to a proper position. Two views of this tube and button attachment are shown (Fig. 965, *b* and *c*). In use the instrument is placed in the mouth, the platinum bar passing readily into the nostril; then the button attachment is slipped over the bar through the external orifice of the nose, the ala being thus distended, and at the same time exerting sufficient pressure to prevent its dislodgement. The fixture is worn with comfort, and the button attachment is tolerated by the nose, the pressure not being sufficient to produce ulceration or absorption. Moreover, while the child's speech, of course, was not immediately improved by the introduction of the palate instrument, the nasal resonance was very markedly lessened instantly by the lifting of the ala. Consequently, it will be but a question of time when her speech will be rendered normal, which it never would have been with one nostril closed.

It may be well to emphasize the fact that the mere insertion of an artificial palate cannot be expected to enable the patient to speak correctly, any more than the possession of a piano or violin would make the

owner an accomplished musician. The artificial palate, properly constructed, supplies the patient with the means of perfecting his speech, but perfection itself must come through practice. Education by a teacher who thoroughly comprehends the needs of the cleft-palate patient will greatly shorten the time required for improvement, as well as ensure a better final result. But the co-operation of the patient is a requisite which is, strangely enough, not always to be counted upon. And it is those persons who have no ambition to help themselves, who have claimed that artificial palates have done nothing for them. An instance of this is noted in a young man at college and approaching manhood who seems to have no conception of the wretched sound of his speech. An instrument admirably adapted to his needs, and one which undoubtedly made it possible for him to attain perfect speech, was worn by him but three months, and then discarded as of no value to him.

One reason why the artificial palate cannot be expected to enable the patient to speak properly at once is this: With normal organs one produces articulate sounds by utilizing the normal actions of his throat-muscles and the tongue and lips. With abnormal organs, as with a cleft palate and hare-lip, the individual, in the effort to produce the sounds which he hears from others, compels his tongue, lips, and throat-muscles to adopt habits which are totally dissimilar to normal movements. When, therefore, the artificial palate is inserted, with which perfect speech can be attained only by normal movements, it is evident that the incorrect habits must first be overcome; and, secondly, the correct action of the organs must be acquired. Consequently, those dentists who report that instruments of their devising correct the patients' defective speech instantly, simply report what is not, and cannot be true if the case be a congenital one.

Since the acquirement of wrong modes of speech must prove so deterring to the patient who essays to improve his speech by resorting to an artificial palate, it is a reasonable corollary that the earlier the instrument is made the less will the patient have to overcome. It is therefore both wise and feasible to insert appliances even before the appearance of the permanent teeth. The co-operation of the patient, however, being of such importance, especially where lessons in articulation are to be given—which is always desirable—it is scarcely wise to undertake a case until the little patient is old enough to appreciate the conditions and their remedy. Therefore, except in rare cases where the child is unusually well developed and mentally bright, it is best to wait until the fifth or sixth year.

This statement is introduced at this point because, whatever doubt there may be in older patients as to the choice between the soft velum and the obturator, with children, and especially young children, *the velum is the one and only best dependence.*

An obturator is an instrument designed to merely fill a gap or close an opening in the palate. To be of any service the instrument must be so constructed that it accomplishes all that the artificial velum enables the patient to do, even though in an entirely different manner. It must accurately fill the cleft when the parts are at rest; *it must also fill the fissure whenever and no matter how far the movable sides of the cleft are drawn upward.* To serve such a purpose the obturator must be so thick

that when the sides of the palate are drawn upward to their greatest limit they still rest against the sides of the obturator. Moreover, it must be of sufficient length to be reached by the posterior wall of the pharynx, and it must be thick enough at the back end, so that when the pharynx does come into contact with it the closure of the posterior nares will be complete. When using the term "thick," allusion is made to the diameter through the obturator from the oral to the nasal surface, not to the thickness of the rubber, for these obturators are hollow bulbs, and the rubber has but the thickness of a single sheet.

In Fig. 967 is shown a model with an obturator in position. The

Fig. 967.

plate is made of iridio-platinum and the obturator is a hollow bulb of hard rubber. This figure shows the length of the obturator in relation to the uvulæ, as well as the manner in which the oral surface of the instrument fills the gap and completes the arch of the vault. In Fig. 968 the same instrument is shown in profile. It is seen that the rubber

Fig. 968.

bulb is attached to the metal plate by passing over a bar which is soldered to the plate, a nut holding it fast. Thus the bulb may be removed in order to repair or alter clasps or to do anything requiring the operation of soldering, which would be difficult to properly perform were the rubber bulb permanently attached. The figure also shows the thick-

ness of the obturator, which is so shaped that as the divided palate rises contact is preserved. This instrument is a modification of the original Suersen device.

In use, an obturator of this kind, unlike the artificial velum, is stationary in its position, but it is of such form that the pharyngeal muscles of the throat in the movements incidental to the production of articulate sounds hug the obturator, and so separate the cavity of the nose from the cavity of the mouth.

In the *American System of Dentistry* (vol. ii. p. 1068) there is figured a Suersen obturator, modified by the addition of a hinge, for which the following claim is made: "The main advantages of this appliance are—that it is made of a durable material, is easily constructed, and that *articulation can be learned with it more readily than with any other appliance.*" This claim appears to be based upon the operation of the hinge which unites the obturator with the plate, but this is a misleading device. To the inexperienced it might appear to be an improvement, but in actual practice it will be found to possess no advantage over the Suersen obturator without the hinge.

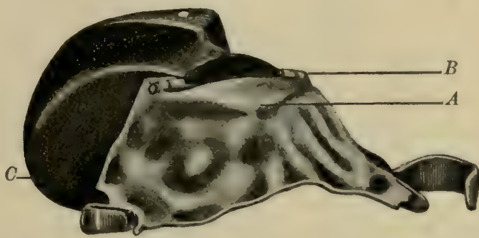
FIG. 969.

That the reader may better comprehend the explanation of this fact, illustrations of a hinged obturator have been inserted. Fig. 969 gives a view from the oral aspect, while Fig. 970 shows the upper side. In both figures *A* represents the metal plate, *B* the hinge, and *C* the rubber bulb or obturator.

Unlike the artificial velum, the obturator may be immovable and yet subserve its purpose, because the soft parts throughout all their varied motions are always in contact with the instrument, the utterance of articulate sounds being thus rendered possible. The addition of the hinge is intended to allow the lifting of the obturator. Even granting that the levator muscles would be powerful enough to accomplish this, the question arises, What will be gained? Unfortunately, nothing, because the same benefits will obtain with an instrument of exactly the

same shape, immovably attached. But when further examination of this sort of appliance is made in the mouth, it is readily seen that *the*

FIG. 970.



levator muscles do not lift the hinged obturator, but, on the contrary, they raise the sides of the cleft, which slide along the bulb exactly as though it were immovable.

The original of the instrument shown in Figs. 969 and 970 was made for a patient who for years had been wearing a soft-rubber velum, with which he had learned to speak correctly. This hinged obturator did not rise and fall as it was expected to do, and the patient discarded it and reverted to the velum. Nevertheless, with the hinged instrument this patient talked very well, the reason being that, *having learned to speak with his velum, he could speak with the obturator, and this in spite of the failure of the hinge action.*

One of these appliances was made for a young lady who was assured that she would speak well within a year, but at the end of three years no improvement was noticed. An examination of the appliance in the mouth showed that the levator muscles did not lift the bulb at all, and it was more of an embarrassment than an advantage. Unlike the previous case, where the patient had learned to speak with a soft velum, this hinged instrument was the initial effort made for her relief. Again the hinge failed, and the obturator was practically the same as one constructed without a hinge. But this patient found her appliance of no benefit to her, whereas when she was given the same plate with the same hinge, *but with a soft-rubber velum attached to it,* a course of instruction covering a few weeks enabled her to speak quite well, and she will unquestionably continue to improve until her speech is perfect.

These two cases emphasize the fact, which should be prominently borne in mind, that the soft-rubber velum is the instrument best adapted for correcting the speech of cleft-palate patients : that having learned to speak by using a soft-rubber velum, these persons will do well with a Suersen obturator, with a hinged obturator whether the hinge works or not, and in some cases even with the crude class of instruments designed for no other purpose than to stop the opening in the hard palate.

There is but one possible condition where a hinge is needed in connection with a hard-rubber bulb, and that is where a surgical operation has failed, a bridge having been constructed across the centre of the fissure, leaving a cleft posteriorly and a perforation anteriorly. The instrument for such a case may be a hard-rubber bulb which passes through the anterior opening, filling the posterior cleft and reaching to

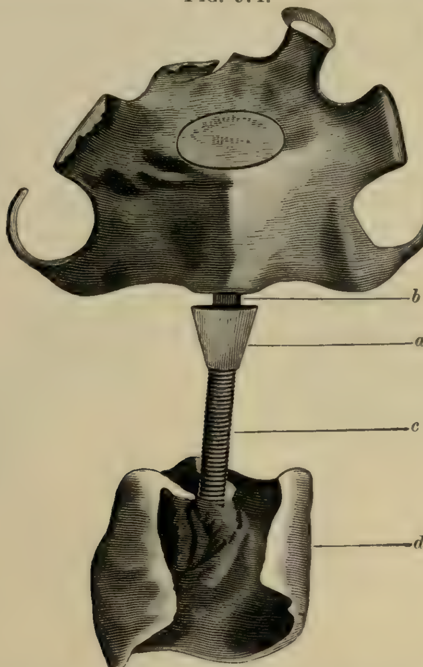
the pharyngeal wall during the act of speaking. Such a bulb is hinged to the plate, and it necessarily rises and falls, because it rests upon the upper side of the surgical bridge, and the levator muscles cannot elevate the halves of the divided palate without raising this bridge and with it the extension which carries the obturator. It is rare that such an anterior opening will permit the passage of the hard bulb, though such cases have been treated.

The history of an instructive case which passed through the writer's hands a few months ago is here given. Before describing this case reference must be made to another sort of obturator which had been employed in this instance. The object in hinging a hard-rubber obturator is to furnish an instrument which will simulate the action of the artificial velum. In Germany the same result had been sought in a different manner. I do not know who claims to be the inventor of the method, but the one which was seen in this case was made by Dr. C. Schultsky of Berlin. This was merely a soft-rubber obturator—in other words, a soft-rubber bulb—hollow like the hard-rubber bulbs, but so fashioned that it could be inflated something after the manner of the pneumatic bicycle tire. The idea evidently is that the soft-rubber ball, placed in the back of the throat, may be compressed by the muscles, thus serving to fill the gap under all circumstances. The history of the patient is as follows:

Mr. F—— was born in Posen, Germany, in 1861, and was thirty-four years of age when he presented himself for treatment. At birth he had a fissure of the soft palate which reached forward to the border of the hard palate, but did not extend into the bone. Nevertheless, he had a hare-lip, which was operated upon during infancy with but partial success, an opening being left near the nostril. At thirteen Dr. Suersen made for him an obturator having a hard-rubber bulb. This was worn for a year, when the clasp on one side was broken and the fixture was abandoned. At the age of twenty Prof. Wolf of Berlin accepted him as a patient at his private clinic and undertook to close the cleft surgically, and at the same time performed a supplementary operation on the lip. This latter operation was a complete success, and Mr. F—— has now a good lip both in appearance and usefulness. A heavy moustache almost completely covers the scar, so that there is no external evidence of his deformity The operation upon the cleft, however, was another addition to the list of cases where the failure of surgical measures has rendered the dentist's work more complicated, without compensating advantage to the patient. The cleft originally extended to the border of the hard palate, so that it would have been comparatively simple to provide for him an artificial velum similar to that shown in Figs. 963 and 964. After learning to speak he could then have had an obturator should he have desired it. The operation, however, by partly closing the cleft constructed a bridge of soft tissue over which a plate could not be worn, so that it became necessary to have an extension to the plate which should carry the appliance used to fill the gap. Thus the patient was very much worse off after, than before his operation. A year later he placed himself under the care of a dentist, Dr. C. Schultsky of Berlin, who made for him a soft-rubber obturator. All that remains of this instrument is shown in Fig. 971. This consists of a vulcanite plate clasped to the

natural teeth and carrying a few artificial teeth. Immediately at the posterior border is a small extension (*a*), also of vulcanite, which is connected

FIG. 971.



with the plate proper by a gold slide (*b*) which moves forward and backward in a metal slot, thus providing for antero-posterior movement. Next there is a gold spiral spring (*c*), which permits the obturator to follow the play of the muscles in any direction. At the posterior end of the gold spring was permanently fastened a soft-rubber bulb or ball (*d*). Judging from what was left of this bulb, it may be inferred that originally it was quite thick along that portion which formed the palatal surface and was intended to complete the arch of the vault. Into this thick portion the spring was fastened. Thinner walls extended upward, completing the bulb and leaving it hollow. There was some sort of orifice and stop-valve, inadequately described by the patient, through which he was instructed to inflate the bulb every morning, the air gradually escaping during the day.

He wore this instrument for five years; during this time, however, the bulb burst, whereupon he continued to wear it in its ruptured condition. Then he had a second bulb attached by the same dentist, which after a brief time also burst. Nevertheless, he continued to use this appliance for eight years more, and the figure shows the fixture as I found it. Two facts in connection with this case are peculiarly instructive: so long as the original bulb remained whole there was no improvement in the patient's speech; second, after it had burst he noticed a very rapid change, and within two years he was speaking with approximate correctness. Thus the ruptured bulb was better than the soft-rubber obturator which it was intended to be; and the point of

great interest here is that, though in a very crude way, still in principle, *the bulb became a Kingsley soft velum as soon as it was ruptured.* This can be better comprehended by comparing Fig. 971 (Dr. Schultsky's instrument with bulb ruptured) with Fig. 972 (which shows the appliance constructed for him by the writer). It will be seen at a glance that the velum here appears to differ from the typical form shown in Figs. 960, 961, and 962 in that there is but a single flap. It is therefore necessary to explain how it is that the principle is the same though the form is different. The typical velum has two flaps, one of which lies in the upper cavity resting upon the sides of the cleft, while the lower flap is below, the two forming grooves in which the sides of the

FIG. 972.

cleft move. When closed, the uvulæ, or extreme posterior ends of the split velum, approximate one another, hugging the artificial velum closely.

FIG. 973.

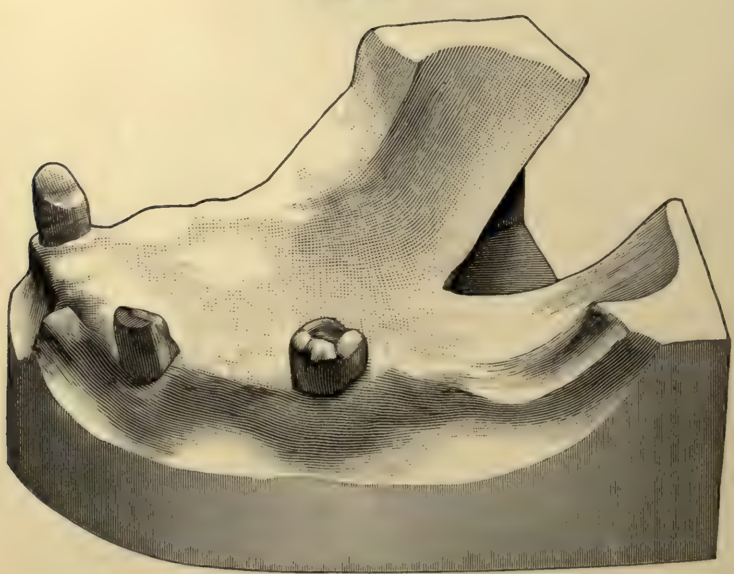
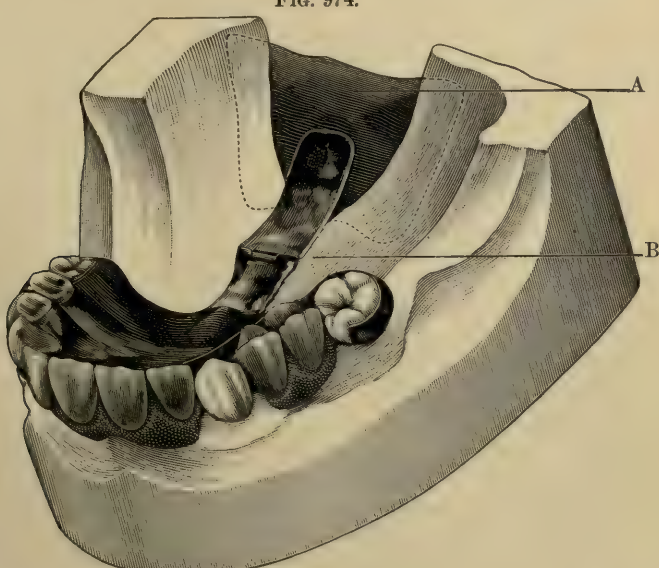


Fig. 973 shows a model of Mr. F——'s mouth, and the absence of the uvulæ will be observed. The uvulæ were originally present, but were destroyed by the surgical operation, and the sides of the cleft poste-

riorly are now continuous with the pillars of the fauces. Here, therefore, there was no need for grooves, there being no possibility of the close approach of the sides of the cleft. A single flap was made, such as is shown in Fig. 972. The anterior edges were made heavier than usual, to offer sufficient resistance to ensure the raising of the hinge extension which connected the velum with the plate in the roof of the mouth. The single flap is similar in the theory of its office to the single flap of Dr. Sercombe, but modified to assume the more practical form seen in the upper flap of the Kingsley velum. Dr. Sercombe claimed that the flap should not reach the posterior wall of the pharynx; in this he made a grave error.

Here, then, may be indicated the reason why the hinge is of no value with an obturator, and yet becomes a necessity with such a case as the last two—viz. where the apex of the fissure is distant from the posterior border of the hard palate. Obturators are constructed of hard rubber, have sloping sides, and are highly polished. In the efforts to close the cavity of the nares the levator muscles draw the sides of the cleft upward and slightly backward, and if a patient can be made to swallow with the mouth open, the operator will readily discover that *the tissues slide along the smooth sides of the obturator, but do not raise it.* The hinge, therefore, is useless. With the other condition a totally different result obtains. The soft velum, lying entirely upon the upper surface of the cleft, and the anterior edge of the velum being stiff and wide, while the apex of the fissure presents the usual angle, it fol-

Fig. 974.



lows that *the natural palate cannot rise without carrying the superincumbent velum with it.* This it could not accomplish if the extension which connects the velum with the plate were unyielding. Consequently, the hinge is a positive necessity. Fig. 974 shows the model of Mr. F——,

with appliance in position, the dotted line indicating the border of the velum, which is above the fissured sides of the palate, and making it clear that no movement can displace it, while the least retraction of the tissues must be followed by a responsive movement of the velum and the hinged extension. In the figure the velum is seen at *a* and the hinge at *b*. The plate in this instance was made of vulcanite to suit the wishes of the patient, his original plate having been of that material. Metal would have been preferable.

Fig. 975 is of special interest: it shows a similar instrument having a hinged extension, but the soft velum is of the typical form, because,

FIG. 975.

although there was a great space between the border of the hard palate and the apex of the fissure, thus necessitating the hinged extension, nevertheless the fissure itself was fairly regular, the uvulæ being present, and the two sides of the cleft when shutting off the cavity of the nares working co-ordinately. The model of this case is seen in Fig. 958, while the instrument with tiny velum is shown in Fig. 975. In connection with hinged artificial palates it is also of interest to record the fact that this case was treated by Dr. Kingsley some twenty years ago.

TAKING THE IMPRESSION OF CLEFT PALATE.

No appliance made by the dentist needs to be more accurately fitted than an artificial palate. It is obviously a corollary, therefore, that the plaster model should be as nearly as possible an exact reproduction of the mouth which it represents.

To obtain such a model requires skill, but not more than should be possessed by the qualified practitioner. Yet the difficulty of taking the impression is the obstacle which has hindered many from attempting to treat these cases, while the ultimate failure of many others who have essayed to make instruments is directly traceable to their inaccuracy in this initial step.

The ordinary impression taken for artificial dentures is easy, because a model is required only of that portion of the mouth, the tissues of which overlie bone. Therefore, whether the impression material be introduced hot or cold, hard or soft, in large or small quantity, the resultant impression is approximately the same, because of the resistance offered by the roof of the mouth against which it is pressed. When, however, too much material is carried into the mouth, so that it extends beyond the border of the hard palate, the common experience is what is called "gagging." A consideration of what this "gagging" is, will make more readily understood a fundamental principle involved in all cleft-palate cases.

The soft palate is sensitive, and when the impression material is brought into contact with it, the result is an irritation or tickling, where-

upon the involuntary muscles of the throat endeavor to draw the parts away from the intruding substance. Thus the velum is elevated, and consequently were a model to be made from such an impression it would be inaccurate as to the posterior portion of the mouth, in that it would not be a representation of the parts at rest.

With the velum divided as in cleft palate, the disturbance of these sensitive tissues upon the introduction of the impression material is even greater. The two halves of the soft palate are not only drawn upward, but they also approach each other. Thus the resultant model will show the cleft *narrower than it really is when the parts are at rest, and the pose of the divided palate will be wrong,* so that no proper calculation can be made for restoring the true arch of the vault. This will obtain whether the impression be taken with plaster of Paris, or with impression compound softened by heat. Where the impression compound, however, is not very soft, or where the divided palate is lacking in vital response, the impression material will merely press the soft tissues before it, the final model being absolutely worthless.

Thus it is seen that no one can obtain an absolutely accurate *impression* of the divided velum *in its normal pose.* Nevertheless, a *model* may be made which will be as accurate as any model of the mouth can be.

The method of procedure is as follows: Select an impression-tray of the ordinary form, just large enough to embrace the arch without stretching the mouth, and long enough to reach slightly beyond the posterior border of the hard palate. In the majority of cases this will answer all purposes, but occasionally it may be advantageous to extend the cup by adding to it a flap of sheet gutta-percha. This may be carried back as far as the uvula, but should not touch the velum at any point. This is to be ascertained by introducing the cup empty.

Plaster of Paris is mixed in the usual way, a little salt being added to hasten the setting, and warm water used to render it more acceptable to the mouth. A pinch of powdered vermilion will color the impression, which will aid in separating, and is preferable to placing the color in the plaster for the model. The plaster is placed in the tray in quantity proportionate to the height of the roof, less being used where the cleft is in the velum only, than where the fissure enters the hard palate also. The use of too much plaster is to be avoided, lest it escape and trickle down the throat. The impression-tray is to be carried into the mouth just as the plaster gives evidence of setting, and is pressed up quickly and firmly, and then held steadily until sufficiently hard for removal. With a little practice the calculation can be made with such nicety that the time required will be not more than one minute. The plaster which remains in the vessel in which it was prepared will be a guide to its setting, and as soon as it will fracture sharply the impression should be withdrawn.

Where the fissure extends into the hard palate it will occasionally occur that the plaster which passes up into the nasal cavity cannot be withdrawn with the impression; but if the impression be removed at the proper moment, the plaster will fracture along the line of the fissure, and that portion left up in the nares may be taken away with the tweezers.

Before passing to a consideration of constructing the model one or two other points in relation to the impression are to be considered.

Ordinarily, all that is required in a model from which to make an instrument for a cleft-palate patient will be absolute accuracy as to the oral aspect of the parts and the borders of the fissure from its apex to the uvulæ. It will very rarely be essential to procure a perfect impression of the upper or nasal side, except that the operator should observe the thickness of the tissues along the borders of the cleft, the position of the vomer, and whether it is likely to interfere with the design of the instrument, as it often will where the fissure only slightly enters the hard palate. In such cases it becomes important to know how close the insertion of the vomer is to the border of the cleft at the apex. This is readily accomplished by placing a small quantity of plaster up into the nasal cavity at the apex of the fissure, carrying it into place with a narrow-bladed knife, or other suitable instrument, just before introducing the impression. This may come away with the impression, or it may fracture and remain in place, in which case it is to be removed with tweezers and added to the impression.

Fig. 976.

A method of obtaining the impression of the upper nares is described in the *American System of Dentistry* as follows: "This impression, if properly obtained, will show a distinct outline of the cleft and uvula. The portion of the plaster occupying the fissure or cleft is next cut down to a smooth surface, and a little forward of the median line of the cleft a hole is drilled through the cup and impression; in addition to this, two pits are made in the smooth surface which represent the cleft, in the same manner as would be done in a cast for a spider articulator, to receive corresponding elevations in the second half of the impression. The whole surface of the impression is then painted with sandarac varnish, vaseline, or solution of soap to prevent adhesion. The next procedure is to pass a rubber tube through the hole in the impression, replace it in the mouth, one end of the tube extending through on to the nasal surface, the other being carried forward and held with the cup in position by an assistant. In the outer end of the tube is placed the nozzle of a syringe; a two-ounce vaginal syringe answers the purpose (Fig. 976). After withdrawing the piston the required quantity of plaster should be mixed to the consistency of cream in a vessel with a spout, by which it can be poured into the syringe. These preparations having been made, the assistant is instructed to hold the syringe in position, and the plaster is poured into it and the piston replaced. Slight pressure on the handle will force the plaster through the rubber tube on

to the smooth surface and adjacent parts of the impression already taken, the patient being instructed to incline the head forward if the plaster is felt to be running down the throat, or backward if it runs too far in the opposite direction, the object being to keep it on a level if possible.

"Precaution should be taken before the plaster sets to remove the rubber tube and syringe and cleanse them thoroughly for future use. When the impression is ready for withdrawal — and it is not necessary for the plaster to set very hard—remove the lower or palatal portion with the cup; the nasal portion can be readily withdrawn afterward with a pair of tweezers."

If this method is intended to be utilized in cases where the fissure is exclusively in the soft palate, it is lacking in utility, *for no possible occasion for an impression of the nasal cavity is conceivable*, the position of the vomer and turbinated bones being normal, and the artificial palate never needing to reach farther forward than the apex of the fissure.

Where the fissure partly enters the hard palate, as has been already stated, the exact position of the vomer must be comprehended. The reason is that where an artificial velum is used, it engages the fissure, so that a flap extends slightly over the border at the apex on the nasal side. In some cases the insertion of the vomer into the hard palate is so near to the border at the apex that the artificial velum might rest against it and cause irritation, unless provision be made to guard against this. But the simple method of carrying a little plaster through the fissure at this point before inserting the impression, as previously described, accomplishes the required result perfectly, without resort to such an intricate process as the one quoted.

Where the fissure involves the whole or greater part of the hard palate it may occasionally be required to secure an accurate model of the nasal cavity as well as of the oral. An example of such an instance is shown and described in connection with Figs. 909 and 910.

The impression here is obtained by carrying the plaster, mixed fairly stiff, up into the nasal cavity, filling it to the borders of the fissure, whereupon the tray with additional plaster is carried to place. As the plaster in the tray unites with that which is in the nares, great care must be observed to remove the impression at the first moment when a sharp fracture is possible. With a sudden sharp movement the impression comes away, leaving the plaster in the nares, the fracture along the borders of the fissure being sharp and clean, so that, when the nasal portion is removed by sliding it back toward the throat and allowing it to drop down upon the tongue, it is readily replaced in proper position upon the impression. If the operator is timid about attempting this, after filling the nares with plaster he may allow it to set. Then after oiling the exposed portion of the plaster, which now finishes out the arch of the roof, the impression may be completed without danger of the two parts adhering.

In accidental fissures resulting from disease or other cause we sometimes find merely an aperture in the palate, which may be quite small. In taking an impression the plaster would ooze through this hole and form a knob or button upon the upper side, which of course would remain after the removal of the impression-cup. Then, as the posterior portion of the soft palate would be normal, it might become a very dif-

ficult matter to remove this plaster without permitting it to pass down into the pharynx. In these cases the precaution should be taken to lay across the aperture a bit of Japanese tissue-paper folded two or three times. This paper will yield sufficiently to allow the plaster to take a perfect impression, yet resists its passage through.

The model made from the most accurate impression will represent the cleft with its sides drawn somewhat together and possibly pressed backward. The next step, therefore, will be the correction of these errors, and the production finally of a model which will be an accurate reproduction of the mouth.

A trial-plate made upon the model, with an extension fitting into the fissure, will indicate at once, when carried to the mouth, how much wider the natural cleft is when the parts are at rest. The natural cleft is to be observed closely in connection with this trial-plate, and the cleft in the model is widened and altered by cutting away the plaster with a knife until a trial-plate which exactly follows the outlines of the cleft on the model will similarly fit the cleft in the mouth. At the same time the edges of the cleft in the model may be rounded, and the pitch of the palate corrected to agree with the mouth, by adding plaster with a small camel's-hair brush. In the end the model will not only *appear* to agree with the mouth, but the trial-plate will demonstrate that it *does* agree. It is not guesswork, but absolute accuracy, even the bulbs of the uvulæ being perfectly reproduced.

The Making of Artificial Vela.

With an accurate model from which to work an artificial velum could be made without further reference to the patient, though it might be best for the inexperienced to try in the model of the velum before proceeding to the construction of metal moulds.

The first step in the production of the artificial velum will be to make a model of the palatal flap. The model of the velum, if it is not to be tried in the mouth, may be made of wax, otherwise it will be best to use sheet gutta-percha. The palatal flap is a triangle with rounded angles. The apex of this triangle coincides with the apex of the fissure, and the base extends across from one uvula to the other. This flap should be made just large enough to bridge the gap, as it will be easy to widen it later by scraping the mould should it become needful, whereas if made too large at the outset it might become necessary to make a part of the mould over. The pattern of the flap having been cut out from gutta-percha, it is to be slightly softened and then pressed against the model, so that it assumes the proper form to lie close to the surface of the latter. It will often occur that the edges of the natural cleft are rounded or rope-like, thus showing a depression between the border of the cleft and the maxillary bone. In these cases the upper flap, when moulded upon the model, will assume quite a curl or crimp, especially near the uvulæ. If the model is accurate and the flap is made to properly conform to this peculiarity, when placed in the mouth it will lie close against the soft tissues. Were it left comparatively a plane, the edges would stand off and be quite noticeable to the tongue. This curling is made more apparent because of the fact that the flap is slightly depressed between

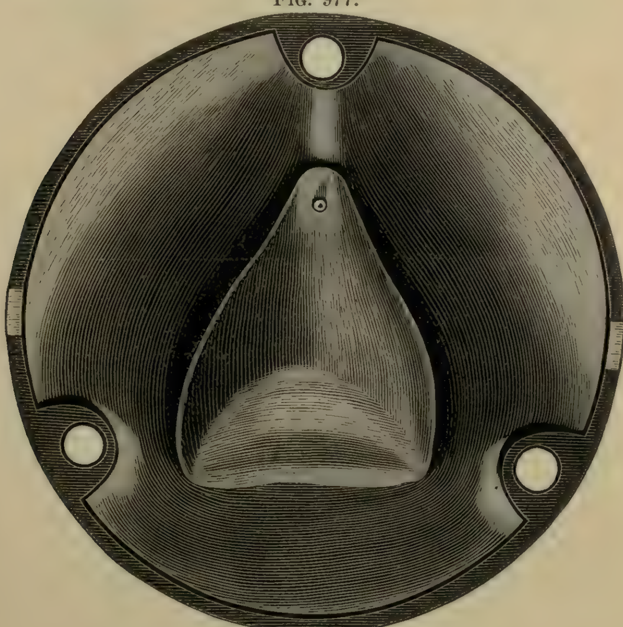
the sides of the cleft, so that it forms a part of the arch of the mouth and completes it. As soon as the flap has been moulded into proper form, all the edges being quite thin, it is plunged into cold water, so that it shall retain its shape.

The second or upper flap is moulded upon the model in a similar manner, the form being again triangular. But the base must now be fashioned so that its posterior edge will meet the ridge of the pharynx at a slight angle. The general adaptation of the flap to the model having been obtained, it is placed in position, and the model and flap firmly held in the left hand, while with the thumb and fore finger of the right hand the operator grasps the flap at the centre of the posterior part and simply bends it up, whereupon it asumes the form shown in Figs. 960, 961, and 962. Usually the guide for bending this tail-piece is to form it so that the plane of that surface will be on a line with the incising edges of the anterior teeth.

The two flaps are next placed upon the model at the same time and waxed together with hard wax. The velum is then ready to be tried in the mouth, when the operator may correct any discrepancies as to fit or length.

The model of the velum having been satisfactorily made, it becomes necessary to produce metal moulds in which soft rubber may be vulcanized into the desired form.

FIG. 977.

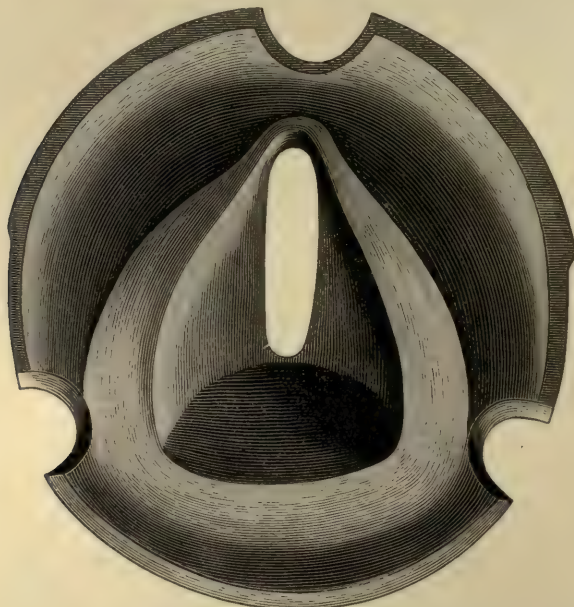


A convenient form of flask for holding these moulds is round and in two parts, one of which has a square hole cut at the centre.

In constructing the moulds the model of the velum is placed in that half of the flask which has the hole, so that the smaller or palatal flap

rests over the hole. The flask having been freely oiled, plaster is poured into it and around the model. When hard it is knocked out readily and carved into shape. It is then varnished, replaced in the flask, and oiled. The model of the velum still being in position, plaster is poured over it and the plaster mould, which now surrounds it, and the opposite half of the flask, well oiled, is put on and pressed firmly to place. When this is hard and separated the two parts of the mould are complete. The third is made by pouring plaster through the hole in the top of the flask,

Fig. 978.



completely filling the space left within the flask, and covering the top flap. These three pieces of plaster are then reproduced by moulding in sand and casting in type-metal. The general appearance when complete is shown in the accompanying illustrations. Fig. 977 is the bottom-piece, in which a pin appears: this is best made of iridio-platinum wire, and is driven into a drilled hole after the mould is cast. In some cases it will be tight enough, but occasionally it may be requisite to fasten it with soft solder. Its purpose is to produce a hole in the velum through which the bar on the plate passes. The two aspects of the central piece of the mould are shown in Figs. 978 and 979, while Fig. 980 shows the top-piece.

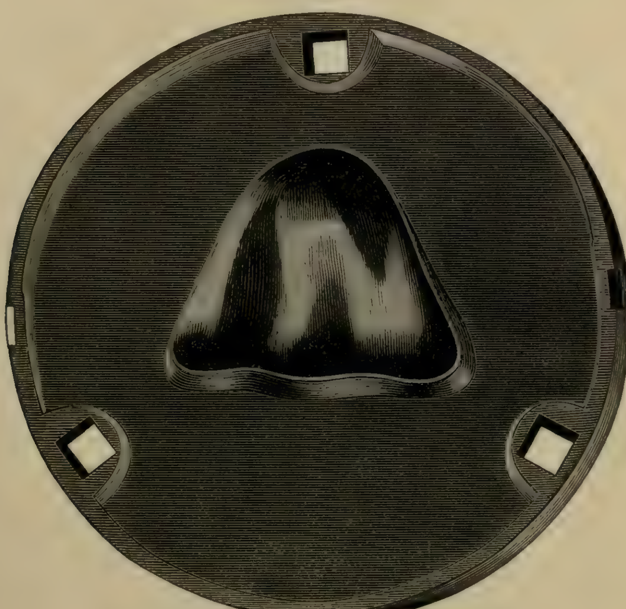
The surfaces for moulding the rubber are to be smoothed with a pine stick and pumice. The metal moulds are returned to their respective positions in the flask sections.

In vulcanizing the soft rubber it is well to slightly soap the surface of the moulds before packing, as this facilitates removal after vulcanization, and avoids a tendency on the part of the rubber to adhere to the metal, especially should any rough places be left, which of course should be avoided.

Fig. 979.

The flask should be opened and excess of rubber removed; otherwise it will be pressed against the unpolished portions of the mould, and ren-

Fig. 980.



der it extremely difficult to open the flask after vulcanization. As soft rubber swells considerably during vulcanization, the mould need not be

quite full, but care should be taken to avoid creases in the rubber, as they will not be filled out however much the rubber may swell, probably owing to the imprisonment of air.

The best results in the vulcanization of soft rubber are obtained by observing the following directions: Place charcoal or other substance in the bottom of the vulcanizer high enough to stand above the water which is poured in. Allow the flask to rest upon this charcoal. In this manner the rubber is vulcanized in steam.

The thermometer which registers the heat should indicate 240° for two hours; 250° for one hour; 260° for one hour; and 270° for one hour.

The velum when taken from the flask will have a peculiar odor if overdone, as though it had been burned. In that case, however perfect and elastic it may appear, it will be worthless within a very few weeks.

The Construction of an Obturator.

An obturator may be made for a patient where the cleft involves the soft palate only, but will be more commonly resorted to where both soft and hard palates are fissured. The process in connection with the latter condition is described, as it is the more intricate.

A correct model having been obtained, the fissure in the hard palate is filled with wax, so that the arch of the vault is restored. Dies are made and a plate of iridio-platinum swaged to fit this reconstructed model, with the result, of course, that when carried to the mouth it bridges over the gap in the hard palate. The plate is provided with an extension at the posterior part which shall support the obturator, and it is attached to the teeth by gold clasps. For this purpose it is best to rely upon the sixth-year molars as offering the best anchorage, and where these teeth are badly decayed it is often advisable to crown them with gold before fitting the clasps about them. Thus the anchorages may be permanently protected against loss by decay.

No matter how valuable teeth may be to ordinary persons, they are doubly so to the cleft-palate patient, who must depend upon them not alone for mastication, but also for speech, since they serve to sustain the instrument which enables him to overcome his infirmity.

The metal plate and clasps having been accurately fitted to the mouth, a loop of copper wire is soldered temporarily to the upper side of the plate (with soft solder) and extended backward about two-thirds the length of the fissure. The object of this is to hold a mass of impression material which is to be used for forming the model of the obturator. This mass of impression material is wrapped about the wire loop and then fashioned into the general shape of the fissure, when it is hardened in cold water. A trial in the mouth will indicate wherein it must be altered by trimming with a sharp knife. The mass having been brought to an approximation of the proper form after this manner, it is then slightly softened in warm water and again placed in the mouth, whereupon the patient is directed to swallow several times. This compels the levator and constrictor muscles to close upon the softened mass and mould it into such shape as will be required to enable the patient to completely close the opening to the nares. Upon removal the mass will

have assumed an irregular shape, which now must be altered to furnish the final model of the obturator. The palatal surface is trimmed into a continuous flat surface, so that in connection with the plate the arch of the vault is completed and the gap in the back of the mouth bridged over. The upper surface is similarly cut away, and is usually best formed with a depression curved laterally, experience having taught that such a form is best adopted for the obliteration of the nasal quality of the voice. Thus the sides and the posterior end are left undisturbed as they were moulded by the action of the muscles.

It must be remembered that no matter how yielding the mass may have been, it is also sufficiently resistant to have prevented the muscles from closing to their utmost limits. It is therefore necessary to trim these surfaces so as to still further reduce the size of the bulb, especially at the posterior end, where the ridge of the pharynx is expected to touch it. In the region of the uvulæ the sides must be trimmed away so that they may close under the obturator, and to this end that part of the bulb may be narrowed at the lower and widened at the upper side, thus producing inclined planes against which the levators will play and be in contact at all times during their contractions. In the region of the uvulæ the bulb may be cut away on a line with the bases of the uvulæ, so that the surface produced will be a plane which if extended by an imaginary line would reach the incisive edges of the anterior teeth.

Figs. 981–983 are introduced to show the great variations in the forms of bulbs, the size and shape being dependent upon the peculiarities of

FIG. 981.

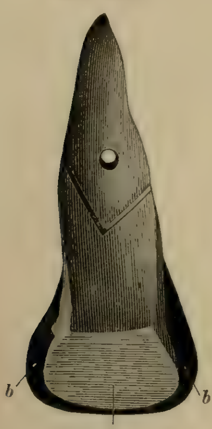
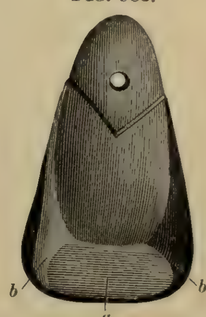


FIG. 982.

FIG. 983.



the fissures and the activity of the throat muscles. In Figs. 981 and 983 *a* indicates the flat surface where, as has been described, the bulb is cut away near the bases of the uvulæ, while *b*, *b* show the slanting sides against which the levatores play. Fig. 982 shows the nasal surface of a large obturator, and along the centre is seen the depression, which, experience has taught, is serviceable in many cases in correcting the nasal quality of the voice usually present. Upon the upper surface the depression alluded to is seen at *c*, but it must be borne in mind

that this is not always a necessity, being less so in small obturators (as in Figs. 981 and 983) than in large.

The model having been brought to this point, plaster is mixed as for an impression, and a little placed upon the upper side of the plate, extended from where the impression material ends sufficiently forward to reach the anterior end of the fissure when placed in the mouth. The plate, with plaster upon it, is then quickly carried into place, and upon removal the plaster will have taken an impression of the forward part of the cleft. It is cut away to a level with the upper side of the impression material, and with it completes the model of the obturator, which must now be reproduced in hard rubber.

Plaster moulds are next made in which to reproduce the bulb in hard rubber, and when flasked and ready for packing the bulb is made as follows: Patterns of the upper and under surfaces are cut from thick tin-foil, and a single pattern to extend around the sides and end. These are similarly cut from sheet rubber, and are united in the general form of the bulb by placing the edges together and pinching them fast with a pair of tweezers. Before finally closing, water should be introduced, filling the bulb about three-quarters full, great care being observed lest the edges of the rubber should become wet, which would prevent perfect union and allow an escape of steam during vulcanization, the result being a collapse of the bulb. If these steps are accurately taken and the flask tightly closed, the bulb will be thoroughly well filled out and will be a perfect reproduction of the model.

The bulb is next to be fitted to the plate, the proper position being determined by models which were taken while the plate and wax (impression material) model were united. A hole is then drilled through the bulb and plate, through which an iridio-platinum bar is passed and soldered to the plate, the opposite end being screw cut and supplied with a nut. The hole drilled through the bulb for the passage of the bar also serves for the removal of the water used in vulcanizing. The surface of the plate over which the bulb is to lie is smeared with gutta-percha, the bulb slipped over the bar, and the nut turned down until it impinges. Then by warming the plate over a Bunsen burner the gutta-percha is softened and the nut screwed down, driving the obturator tight against the plate, the gutta-percha serving to form a water-tight joint. The plate and bulb are then polished and are ready for the patient.

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